Guidelines for effective technology facilitation of Realistic Mathematics Education to enhance teaching practice

DJ Laubscher
10218343

Thesis submitted for the degree Doctor Philosophiae in Mathematics Education at the Potchefstroom Campus of the North-West University

Promoter: Prof AS Blignaut
Co-Promoter Prof HD Nieuwoudt

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I the undersigned, hereby declare that the work contained in this dissertation / thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

________________________
Signature

November 2016
Date

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Acknowledgements

This thesis is dedicated to my late parents Louis and Joy Holmes, who instilled in me the desire to work hard, strive for the best and never give up. They taught me to live by the motto “If something is worth doing, do it well.”

I would hereby like to thank:

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Abstract

Different teaching styles and approaches that are employed in a teaching environment have a huge impact on the achievement of learners. The value of using the Realistic Mathematics Education (RME) teaching approach to teaching Mathematics is evident in a number of studies. This study aimed to determine how the RME approach, facilitated by technology, could be used to enhance teaching practice. It also aimed to establish what support needs in-service Mathematics teacher-students in the South African context had with regard to using the RME approach, and it intended to yield guidelines for the effective use of technology in implementing the RME approach, thereby generating theoretically relevant knowledge to the body of scholarship. A purposeful stratified sample was used to understand what needs in-service Mathematics teachers had in terms of making Mathematics more realistic for their learners. Participants were selected from a group of in-service teachers enrolled for the BEd Honours post-graduate degree in Mathematics education at the NWU. Qualitative design-based research was an appropriate methodology for this study. I produced, evaluated and adjusted content based on the RME approach, presented by means of a mobile application to assist teacher-students in presenting learning content to their learners in a more realistic and relevant way. The first stage of the study consisted of a systematic literature review (SLR) to determine how the RME approach could be facilitated by technology to enhance teaching practice. Individual interviews with participants followed, to determine their needs in terms of effectively implementing the RME approach in their teaching practice. Thereafter iterative cycles of design and intervention took place. A mobile application (app) was used to present content to the participants, based on the needs identified in the individual interviews and the literature review. The re-design of the intervention was guided by testing different versions of the prototype of the app with various users, as well as by literature. Focus group interviews were used to establish the teacher-students’ perceptions and evaluation of the app. The final stage of the study produced guidelines based on the findings of the study. Data were coded, sorted and summarised into themes using a computer assisted qualitative data analysis software (CAQDAS), ATLAS.ti™. The data analysis and interpretation were integrated with the literature review to answer the research questions. Based on these findings, guidelines for the effective use of technology in implementing the RME approach in teaching practice were designed. These guidelines were designed around the five dominant themes in the study, namely Mathematics, RME, ICT, role-players and aspects relating to the app. The guidelines will be of value to teachers, their learners, lecturers, curriculum specialists and instructional designers in the design, implementation and adaptation of mathematical content and course material.

Keywords:

Mathematics Education; Realistic Mathematics Education (RME); mLearning; Mobile App; Systematic Literature Review (SLR); qualitative data analysis; Interpretivist; ATLAS.ti™; teacher-students; open distance learning (ODL).
Verskillende onderrigstyle en benaderings tot onderrig het 'n geweldige impak op die prestasie van leerders. Die waarde van die gebruik van die Realistiese Wiskunde-onderrig (RWO)-benadering word genoegsaam gesteun deur navorsing. Hierdie studie het gepoog om te bepaal hoe die RWO-benadering, gefasiliteer deur tegnologie, gebruik kan word om die praktyk van onderrig en leer te verbeter. Dit het ook gepoog om te bepaal watter ondersteuningsbehoeftes praktiserende Wiskunde-onderwysers wat deeltyds studeer, spesifiek in die Suid-Afrikaanse konteks, het t.o.v. die gebruik van die RWO-benadering. Voorts het dit gepoog om ook spesifieke riglyne daar te stel vir die effektiewe gebruik van tegnologie tydens die implementering van die RWO-benadering, wat 'n bydrae sal maak tot die relevante teoretiese kennis in hierdie vakgebied. ‘n Doelgerigte gestratifiseerde steekproef is gebruik om te bepaal watter ondersteuningsbehoeftes praktiserende Wiskunde-onderwysers het, om Wiskunde meer realisties te maak vir hulle leerders. Deelnemers is geselekteer vanuit ‘n groep praktiserende Wiskunde-onderwysers wat deeltyds studeer, en ingeskrewe BEd Honneurs-studente (Wiskunde-onderrig) by die Noordwes-Universiteit is. ‘n Kwalitatiewe ontpwerp-gebaseerde navorsingsmetodologie is gebruik vir hierdie studie. Ek het die inhoud geproduseer, beoordeel en aangepas n.a.v. die RWO-benadering. Dit is gedoen m.b.v. ‘n mobiele toepassing wat praktiserende Wiskunde-onderwysers wat deeltyds studeer, kan gebruik in ‘n poging om die leerinhoud meer realisties en relevant aan te bied. Die eerste fase van die studie bestaan uit ‘n sistematiese literatuurstudie om te bepaal hoe die RWO-benadering gefasiliteer kan word d.m.v. tegnologie in ‘n poging om onderrigraktyk te verbeter. Individuele onderhoude met die deelnemers is daarna gedoen met die doel om die behoeftes t.o.v. die effektiewe implementering van die RWO-benadering in die onderrigraktyk te bepaal. Ontwerpsiklusse wat beide herhalend en ingrypend van aard was, is toegepas. ‘n Mobiele toepassing wat ontpwerp is na gelang van die bepaling van behoeftes soos geïdentifiseer deur die individuele onderhoude en die literatuurstudie, is gebruik om inhoud aan te bied aan die deelnemers. Die herontwerp van die ingryping is bepaal deur die toetsing en evaluasie van verskillende weergawes van die prototipe, en is voordurend aangepas na gelang van toetsing en terugvoer van verskeie gebruikers, ondersteun deur die literatuur. Fokusgroep-onderrhoude is gebruik om die deelnemers se persepsies en evaluasie van die toepassing te bepaal. Die finale fase van die studie het riglyne opgelever gebaseer op die bevindings van die studie. Data is gekodeer, sorteer en opgesom en vervat in verskillende temas deur gebruik te maak van ‘n kwalitatiewe rekenaardata-analise-sagteware, ATLAS.ti™. Die data-analise en interpretagie is geïntegreer met die literatuuroorsig met die doel om die navorsingsvraag te beantwoord. Riglyne vir die effektiewe gebruik van tegnologie in die implementering van die RWO-benadering in onderrigraktyk is ontwerp, gebaseer op die bevindings uitgewys deur die data. Hierdie riglyne is ontwerp en het gefokus op die vyf dominante temas in die studie, naamlik Wiskunde, RWO, IKT, die verschillende rolspeilers en aspekte m.b.t. die toepassing. Die riglyne sal van waarde wees vir onderwysers, die leerders, lektore, kurrikulumspesialiste en onderrigontwerpers tydens die ontwerp, implementering en aanpassing van wiskundige inhoud en Wiskundige kursusmateriaal.
**Sleutelwoorde**

Wiskunde-onderrig, Realistiese Wiskundeonderrig, mobiele leer, Mobiele Toepassing, Sistematiese literatuuroorsig, kwalitatiewe data-analise, interpretivisties, ATLAS.ti™; praktiserende onderwysstudente, oop afstandsleer (OAL).
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACE</td>
<td>Advanced Certificate in Education</td>
</tr>
<tr>
<td>ANA</td>
<td>Annual National Assessment</td>
</tr>
<tr>
<td>App</td>
<td>Application</td>
</tr>
<tr>
<td>BEd</td>
<td>Bachelor of Education</td>
</tr>
<tr>
<td>CAQDAS</td>
<td>Computer Assisted Qualitative Data Analysis Software</td>
</tr>
<tr>
<td>DBE</td>
<td>Department of Basic Education</td>
</tr>
<tr>
<td>DE</td>
<td>Distance Education</td>
</tr>
<tr>
<td>ECAR</td>
<td>Educause Centre for Analysis and Research</td>
</tr>
<tr>
<td>FET</td>
<td>Further Education and Training</td>
</tr>
<tr>
<td>HEI</td>
<td>Higher Education Institution</td>
</tr>
<tr>
<td>HHT</td>
<td>Hand-held Technology</td>
</tr>
<tr>
<td>HLT</td>
<td>Hypothetical Learning Trajectory</td>
</tr>
<tr>
<td>HOD</td>
<td>Head of Department</td>
</tr>
<tr>
<td>HU</td>
<td>Hermeneutic Unit</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Education Technology</td>
</tr>
<tr>
<td>iOS</td>
<td>iPhone Operating System</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IWB</td>
<td>Interactive Whiteboard</td>
</tr>
<tr>
<td>MKT</td>
<td>Mathematical Knowledge for Teaching</td>
</tr>
<tr>
<td>NCTM</td>
<td>The National Council of Teachers of Mathematics</td>
</tr>
<tr>
<td>NSLA</td>
<td>National Strategy for Learner Attainment Framework</td>
</tr>
<tr>
<td>NWU</td>
<td>North-West University</td>
</tr>
<tr>
<td>ODL</td>
<td>Open and Distance Learning</td>
</tr>
<tr>
<td>PCK</td>
<td>Pedagogical Content Knowledge</td>
</tr>
<tr>
<td>RME</td>
<td>Realistic Mathematics Education</td>
</tr>
<tr>
<td>SDL</td>
<td>Self-directed Learning</td>
</tr>
<tr>
<td>TCK</td>
<td>Technological Content Knowledge</td>
</tr>
<tr>
<td>TPACK</td>
<td>Technological Pedagogical Content Knowledge</td>
</tr>
<tr>
<td>TPK</td>
<td>Technological Pedagogical Knowledge</td>
</tr>
<tr>
<td>UNISA</td>
<td>University of South Africa</td>
</tr>
<tr>
<td>UODL</td>
<td>Unit for Open Distance Learning</td>
</tr>
<tr>
<td>VLE</td>
<td>Virtual Learning Environment</td>
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Addendum 9  ATLAS.ti™ Hermeneutic Unit

Addenda are available on the CD at the back of the dissertation.
The ATLAS.ti™ PDF file is available at https://goo.gl/kkVzX6
1.1 Introduction

The effective teaching and learning of Mathematics remains a priority in South Africa (Fleisch & Schöer, 2014, p. 1). Different approaches to the teaching of Mathematics influence learner achievement. The significance of using the Realistic Mathematics Education (RME) teaching approach to assist learners previously taught by traditional approaches is evident in literature. This study aims to determine the needs of in-service Mathematics teacher-students in the South African context with regard to teaching using the RME approach. It also intends to yield guidelines for the effective use of technology in implementing the RME approach; thereby generating theoretically relevant knowledge to the body of scholarship (Gravemijeijer, 1999, p. 113).

The sections that follow in this chapter give an overview of the study in terms of the problem statement and motivation to do the research; a brief literature review which also highlights the gaps in the current literature; the research design and methodology; ethical issues; the way in which data were generated; and also some important terminology referred to in this study. Figure 1.1 represents an overview of what follows in Chapter One.

1.2 Motivation and Problem Statement

A primary concern of the South African Government, on which the Department of Basic Education has to deliver, is to improve the quality of basic education (DBE, 2012, p. 2). The Annual National Assessment (ANA) and the National Senior Certificate (NSC) examination play crucial roles in the Government’s action plan to improve the quality of basic education (DBE, 2013, p. 6). Since the 2015 ANA tests were postponed, the NSC examinations remain the main essential measure for monitoring progress in achieving the targets that have been set in terms of learner achievement for Grade 12s.

The Annual National Assessment (ANA) which monitored learner achievement progress was implemented from 2011 to 2014. It was a diagnostic testing programme that required all schools in the country to conduct the same Language and Mathematics tests, which was grade-specific, for grades 1 to 6 and 9 (DBE, 2012, p. 2). The 2012 ANA, a huge undertaking, assessed the literacy and numeracy of more than seven million learners. The national average percentage marks for Mathematics in 2014 were: grade1: 68%, grade 2: 62%, grade 3: 56%, grade 4: 37%, grade 5: 37%, grade 6: 43%, and grade 9:11% (DBE, 2014, p. 9).
In most cases, except in grade 6 and grade 9, learners performed slightly better in 2014 than in 2013, however there remains a huge concern about the declining trend from lower to higher grades, culminating in the extremely poor results of the grade 9s (DBE, 2014, p. 9).
Not only are there concerns with the Foundation, Intermediate and Senior Phase Mathematics, but also with the grade 12s in the Further Education and Training (FET) phase. One of the targets of the government’s Action Plan to 2014 was to increase the number of grade 12 learners who pass Mathematics (DBE, 2011, p. 8). The percentage pass rates for Grade 12 Mathematics for the past eight years are as follows: 2008 was 45.4%, 2009 was 46.0%, 2010 was 47.4%, 2011 was 46.3%, 2012 was 54%, 2013 was 59.1%, 2014 was 53.5% and in 2015 it was 49.1% (DBE, 2015, p. 58). Despite occasional improvement, there is still great concern about the Mathematics results.

One of the challenges identified by the government during the first five years of the implementation of the National Senior Certificate (NSC) is that there is a concern about the large numbers of candidates enrolling for Mathematical Literacy rather than Mathematics. Since the ratio at present is 2:3 of Mathematics to Mathematical Literacy for grade 10 to 12 learners, the Department of Basic Education (DBE) would like to see more learners taking Mathematics (DBE, 2015, p. 19).

Specific intervention strategies for 2013 have been devised as part of a turnaround strategy within the National Strategy for Learner Attainment (NSLA) framework. One such strategy expects teachers to, amongst other important aspects, not only ensure full curriculum coverage; provide opportunities for more written work by learners, but also improve the quality of teaching and assessment tasks given to learners (DBE, 2013, p. 14). The DBE has prioritised Mathematics, Science and Technology skills in line with the national human resource development priorities. One example of such support is the Dinaledi1 schools’ programme which provides focused support and intervention in Mathematics, Science and Technology in the form of funding for Mathematics and Science equipment, developing learning and teaching support material for Mathematics and Science and training for Mathematics and Science teachers on subject content knowledge (DBE, 2013, p. 15). Furthermore, the Telkom Masters Agreement was signed on 27 March 2012 for the first phase of the Connectivity Plan, which will provide internet connectivity to 1650 schools for a period of three years (DBE, 2013, p. 15) and aims at assisting with the learners’ performance in Mathematics Science and Technology.

Different teaching styles influence learner achievement, and the selection of teaching approaches that are employed in a teaching environment, have a huge impact on the achievement of learners (Samuelsson, 2010, p. 61). Particularly, the traditional approach, where *talk-and-chalk* is the preferred teaching style, is linked to the poor quality of Mathematics education (Bishop, Hart, Lerman, & Nunes, 1993, p. 18). Often learners do not like learning Mathematics because they do not learn the Mathematics that they need in life (Fauzan, Plomp, & Gravemeijer, 2013, p. 162). Various studies have indicated that the RME approach offers great value to learners who have failed to benefit adequately from traditional teaching approaches (Barnes, 2004; Cobb, Zhao, & Visnovska, 2008; Fauzan et al., 2013; Gravemeijer & Doorman, 1999; Webb, 2011).

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1 In 2001 the Department of Education initiated the Dinaledi School Project to try to improve the number of university-entrance passes in Mathematics and Science for Grade 12 learners. The project involved selecting certain secondary schools that demonstrated potential for improving learner performance in Mathematics and Science. These schools were provided with resources and support to improve the teaching and learning of these subjects (DoE, 2009, p. 6).
The development of what is now known as Realistic Mathematics Education (RME) started in the late 1960s and is still under active development. In essence, RME is concerned with the idea of Mathematics as a human activity of making sense of reality so as for it to be useful (Freudenthal, 1973). The relevance for Mathematics education is that the subject is not a closed system, but an activity. The focus should be on the process of mathematizing reality (Freudenthal, 1968, p. 7). This process of mathematization involves providing learners the opportunity to reinvent Mathematics by reorganising or mathematizing real world situations or mathematical processes (Cobb et al., 2008, p. 105). By using technology, teacher-students can learn the RME approach as and when they wish to do so. This can happen during a guided programme or even after the completion of such a programme, since technology makes the availability of information very easy to access (Zulkardi, 2002, p. 157).

The National Council of Teachers of Mathematics (NCTM) claims in their position statement that “it is essential that teachers and learners have regular access to technologies that support and advance mathematical sense making, reasoning, problem solving, and communication” (National Council of Teachers of Mathematics, 2011, p. 1). The importance of technology in teacher education is also emphasised by the NCTM. They assert that teacher education programmes and professional development must continually update specialists’ knowledge of technology and the application thereof to support learning (National Council of Teachers of Mathematics, 2011, p. 1).

Drijvers (2012, p. 1) valiantly raises the question of whether digital technology in Mathematics education works or not. Upon investigation of six cases, which are considered leading studies in the field, he reveals that both success and failure occur at levels of teaching, learning and research (Drijvers, 2012, p. 12). An important observation that is made in this study is that the integration of technology in Mathematics education does not reduce the importance of the teacher. The teacher plays an active role and needs to devise learning activities that relate experiences within the technological environment to mathematical activities (Drijvers, 2012, p. 12). Another important observation is that digital technology should be embedded in an educational context that is coherent and in which the technology is integrated in a natural way (Drijvers, 2012, p. 13). The importance of the teacher in the process of teaching with technology should not be underestimated. The role of the teacher has been acknowledged as a critical factor in the integration of technology into teaching and learning Mathematics. It is considered critical because the way in which teachers approach the use of technology has vast consequences for the effects of its use in the classroom (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010a, p. 213). Ottenbreit-Leftwich et al. (2012, p. 400) assert that technology is an essential part of professional competency and teachers’ appropriate use of technology can have positive academic benefits.
1.2.1 Gaps in the Existing Literature

A study concerning the design, development and evaluation of a learning environment (an RME course created with web support) for student teachers in Indonesia revealed important results (Zulkardi, 2002, p. 46). This learning environment could assist the student teachers in learning the mathematical, didactic and practice part of the RME course, thus promoting their understanding about RME and supporting student teachers in learning how to redesign lesson material for the classroom (Zulkardi, 2002, p. 168). The learning environment also had a positive impact on developing student teachers’ performance, and on increasing the positive attitude of pupils in the secondary school towards Mathematics (Zulkardi, 2002, p. 168).

A research project (Widjaja & Heck, 2003) conducted at an Indonesian Junior School which investigated the effects of teaching and learning in an RME-based and Information and Communication Technology (ICT)-supported learning process revealed that teachers in general considered the experience as positive. The teachers believed that the chosen approach proved to be advantageous for both teachers and learners. Learners obtained results from their own efforts, rather than receiving descriptive material from the teacher, they were acquainted with new technology and their abilities and skills were explored and encouraged (Widjaja & Heck, 2003, p. 41). Advantages for the teacher included, amongst others, that the teachers did not have to spend much time and energy on explanations (Widjaja & Heck, 2003, p. 41). Some recommendations made in the study suggest that this idea should be developed within teacher-training institutes, more material should be provided for teachers and stronger networks among teachers and teacher-students should be established (Widjaja & Heck, 2003, p. 47).

A local study performed at UNISA also reports the successful adoption of the RME theory to teach introductory Calculus concepts within the context of Distance Education (Kizito, 2012b, p. 3). Some important recommendations in this study include that the concepts and mathematical structures that are to be represented should be carefully selected, and the learning activities should be researched, tested and developed by a team of experts which should include mathematicians and Mathematics subject didacticians (Kizito, 2012b, p. 3).

Some limitations highlighted by the studies listed above include the further need to investigate the extent to which the learning environment, which comprises a RME course with Web support, will improve the perceptions and Mathematics learning outcomes of pupils after they have been taught by prospective teachers using the RME approach with Web support (Zulkardi, 2002, p. 172). Additionally, Kizito (2012b, p. 284) suggests that intervention which involves mobile learning (mLearning) requires an institutional approach in order to be effective. Widjaja and Heck (2003, p. 45) also propose that the changing roles of teachers and learners need to be further researched.
Despite a few similar studies in the field, as summarised in Table 1, the need arises to investigate the use of the RME approach facilitated by a variety of technologies, for in-service Mathematics teacher-students in the South African context, with the aim to enhance teaching practice.

Table 1.1: Comparison of similar studies relating to Realistic Mathematics Education, Design-based research and technology

<table>
<thead>
<tr>
<th>Key Factors</th>
<th>UNISA study</th>
<th>Indonesian study</th>
<th>Erkki Sutinen</th>
<th>Andreasen</th>
<th>Current Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>RME</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
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<td>Web-based</td>
<td>Mobile</td>
<td>No technology</td>
<td>Mobile</td>
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<td>Undergraduate Education</td>
<td>Non-students</td>
<td>Undergraduate Mathematics education</td>
<td>In-service</td>
</tr>
<tr>
<td>Mode of delivery</td>
<td>Distance Education</td>
<td>Full-time</td>
<td>Incidental</td>
<td>Full-time</td>
<td>Open and Distance Learning (ODL) and face to face</td>
</tr>
<tr>
<td>Design</td>
<td>Design-based research</td>
<td>Design-based research</td>
<td>Action Research</td>
<td>Design-based research</td>
<td>Design-based research</td>
</tr>
</tbody>
</table>

1.3 Overview of the Literature

1.3.1 Realistic Mathematics Education

Mathematics is of such a general nature that it applies to a richer variety of situations than any other teaching subject (Freudenthal, 1968, p. 5). Many learners are not able to apply their Mathematical classroom experiences in the most trivial situations in daily life (Freudenthal, 1968, p. 5). Freudenthal (1968, p. 5) distinguishes between two attitudes to teaching Mathematics, namely teaching Mathematics without any relation to its use other than hoping that learners will apply it when necessary; and the opposing attitude which is to teach useful Mathematics. Freudenthal (1973) believes that learners should be allowed to reinvent Mathematics by mathematizing real world situations. RME is rooted in Freudenthal’s interpretation of Mathematics as a human activity, which implies an activity of looking for and solving problems, and also an activity of organising subject matter (Freudenthal, 1973).

Mathematizing is distinguished as having a horizontal and vertical component (Treffers, 1993, p. 94). In general terms, these components can be described as follows. In horizontal mathematization, learners devise mathematical tools which can help to organize and solve a problem in a real life situation. Vertical mathematization is the process of reorganization within the mathematical system itself, e.g. finding shortcuts and discovering connections between concepts and strategies and applying these discoveries (van den Heuvel-Panhuizen, 1998). Horizontal mathematization is a process in which learners transform problem situations that they perceive as realistic into a mathematical system (Widjaja & Heck, 2003, p. 9). In RME mathematization takes place in both
directions by means of a process of reinvention which is guided by the teacher and the instructional materials (Widjaja & Heck, 2003, p. 10).

In RME, Mathematics is considered to be a human activity connected with reality, where contextual problems are used as a starting point in learning (Widjaja & Heck, 2003, p. 3). Three basic RME heuristics have been identified by Gravemeijer, Bowers, and Stephan (2003, p. 52). These provide designers with information to assist in supporting learners within the cycles of design-based research. They include the following:

1. sequences must be experientially real for learners (learners must be able to engage in personally meaningful activity, the sequences must be realistic in learner terms);
2. guided reinvention (after the designer has engaged in planning, a sequence of instructional activities are developed);
3. emergence of learner-developed models (learners’ modelling activity is developed to support the reinvention process) (Gravemeijer et al., 2003, p. 52).

These three heuristics work together to assist learners to participate in activities that will develop sophisticated mathematical practices (Gravemeijer et al., 2003, p. 52).

Besides the three heuristics, RME is also characterised by five types of activities (Gravemeijer, 1994, p. 451; Kizito, 2012b, p. 103):

1. **Phenomenological exploration**: Teaching learners ways to manipulate the means of organising phenomena that need to be organised.
2. **Using models and symbols for progressive mathematization**: Attention is given to models, model situations and schemata that arise from problem-solving activities.
3. **Learner contributions**: Learners are encouraged to create their own constructions and productions.
4. **Interactivity**: A learning process is constructed where learners’ informal methods are used to negotiate, intervene, discuss, co-operate and evaluate.
5. **Intertwining**: Problem-solving consists of an interlinking of learning strands.

As far as possible, these activities should be included in a RME approach.

The notion of guided reinvention is closely associated with RME. As Freudenthal (1973) points out, Mathematics is an activity where the most important activity is mathematization, which implies a form of organization from a mathematical perspective. This organisation or mathematization is how the learners can reinvent Mathematics, but it is important to note that learners are not meant to reinvent on their own. Freudenthal (1973) refers to guided reinvention, where the emphasis is not on the invention, but rather on the process that takes place (Gravemeijer & Doorman, 1999, p. 116). The process starts where real life situations are mathematized, and continues where reinvention takes place in which learners also mathematize their own mathematical activity (Gravemeijer & Doorman, 1999, p. 116). In practice this would mean that specific contextual problems are given to learners where they are given the opportunity to create solutions within the given context. The reinvention
takes place when learners use their everyday language to structure the given problems into both informal and formal mathematical forms (Barnes, 2004, p. 56).

In order to apply the principles of RME, the development of a Hypothetical Learning Trajectory (HLT) is required. Simon (1995) refers to HLT which represents a framework for teachers to adapt instructional sequences that suit their needs in the classroom. An HLT comprises three components: the teacher’s goal or aim for learner learning that determines the direction, the actual mathematical tasks that will be used to promote learner learning, and a predicted view or hypothesis regarding the process of learner thinking, learning and understanding that will shape in the context of the learning activities (Baroody, Cibulskis, Lai, & Li, 2004, p. 231; Simon, 1995, p. 133). HLT is the course along which learning might proceed, as predicted by the teacher. The creation and on-going modification and refinement of these learning activities form a cyclical process. As teachers evaluate learners’ thinking and learning, new ideas for learning activities can be planned. These learning activities depend on the teacher’s hypotheses about the development of learners’ thinking and learning (Simon, 1995, p. 136).

A number of key aspects play a role in the teaching process. These aspects include: the teachers’ knowledge of Mathematics, their views about learners’ cognitions, their theories about Mathematics teaching and learning, their knowledge of learning with respect to specific mathematical content, and their knowledge of mathematical representations, materials and activities (Simon, 1995, p. 133). These ideas are reinforced by research done on Mathematical Knowledge for Teaching (MKT).

Mathematical Knowledge for Teaching (MKT) is defined as the “mathematical knowledge needed to perform the recurrent tasks of teaching mathematics to learners” (Ball, Thames, & Phelps, 2008, p. 399). As an extension to the work of Shulman (1986), Ball et al. (2008, p. 403) distinguish between different domains for mathematical knowledge for teaching, namely subject matter knowledge and pedagogical content knowledge, which in turn are subdivided into the following categories: common content knowledge, horizon content knowledge, specialised content knowledge, knowledge of content and learners, knowledge of content and teaching and knowledge of content and curriculum. When referring to the mathematical knowledge that teachers need to teach, Ball et al. (2008, p. 395) consider “teaching” to entail the following activities: planning the lessons, evaluating learners’ work, designing and assessment, explaining classwork to parents, designing and managing homework and dealing with equity. Mishra and Koehler (2006) also expand on the work of Shulman (1986) by introducing the knowledge of technology as an essential knowledge domain. The Technological Pedagogical Content Knowledge (TPACK) framework presents the three main components of teachers’ knowledge: content, pedagogy and technology. Not only are these aspects important, but the interactions between them which are represented as PCK (pedagogical content knowledge), TCK (technological content knowledge), TPK (technological pedagogical knowledge) and TPACK (technological pedagogical content knowledge) are essential (Mishra & Koehler, 2006, p. 62). The role of a teacher’s MKT is therefore vital in his or her construction of an HLT.
1.3.2 Information and Communication Technology and Mathematics Education

The positive effects of using technology in teaching and learning situations are becoming more apparent (Bennison & Goos, 2010, p. 31; Chinnappan, 2003, p. 35; Li, 2003, p. 72; Mistretta, 2005, p. 18). Training teachers to integrate technology in the classroom and continuing to investigate the effects of technology on teaching and learning are two ways to empower technology-based learning environments (Mistretta, 2005, p. 23). The need to assist both pre-service and in-service Mathematics educators to develop the ability to effectively make use of technology in their classrooms is becoming more pronounced and important. It is suggested that technology is best learned in context and should thus be integrated into coursework and field experience (Li, 2003, p. 62). Li (2003, p. 62) believes that teacher-students should see their professors modelling or demonstrating the use of technology.

In a study that explored the use of the Internet (discussion forums, online material, e-journaling, computer games) in a Mathematics education course, teacher-students felt that instructional technology could be an effective tool for their own learning. They also indicated that the use of the Internet in the course assisted them with aspects like improving communication with one another, which in turn could enhance their understanding of educational theories. Other advantages of using instructional technology that they mentioned, include that it gives time for synthesis, it enhances learning by providing visual and interactive experiences, and it saves time (Li, 2003, p. 72).

Although teachers use technology to display or present content, many are not aware of the potential that technology has to promote concept development in the Mathematics classroom (Serow & Callingham, 2011, p. 161). The role of the teacher in integrating technology in Mathematics education is extremely important. The teacher has to coordinate learning by creating technology-rich activities, use appropriate tool techniques and relate the experiences in the technological environment to mathematical activities. To achieve this, a process of professional development is needed (Drijvers, 2012, p. 12). Serow and Callingham (2011, p. 171) who conducted research on the use of the Interactive Whiteboard (IWB) in teaching primary school Mathematics, suggest that Mathematics teachers require time to explore and develop teaching materials and should be allowed to work with a mentor from an early stage when it comes to effective professional development.

Facebook was originally designed as a social networking website, but has proceeded to be used in educational settings as well. Grossecka, Branb, and Tiruc (2011, p. 1426) review characteristics from literature concerning learners and teachers. The learners recommend Facebook as a tool that has the potential to contribute significantly to the educational arena. For the learners, some advantages include the following: to be involved in achieving learning tasks; to develop communication, cognitive and social competencies; to create their own learning path by establishing links and connections; to consolidate self-confidence and self-esteem and to communicate with the teacher outside the class.
For the teacher, the following benefits are highlighted: to practise a differential pedagogy in the best interest of the learners; to perform mentoring; to interconnect learning experiences; to expand the communicative experience with the learners concerning didactic issues and to give up on old behavioural patterns (Grossecka et al., 2011, p. 1427).

GeoGebra is freely-available open-source dynamic Mathematics software which incorporates Geometry, Algebra, Calculus and a spreadsheet into a single software package. To merely provide teachers with technology is not enough for them to successfully integrate the technology into their teaching (Hohenwarter & Lavicsa, 2007, p. 49). Hohenwarter and Jones (2007, p. 130) assert that, apart from online collaboration, teachers should also be offered professional development in terms of the use of technology in their teaching and also research activities should be coordinated, especially in relation to GeoGebra.

1.3.3 Realistic Mathematics Education and Technology

As the TPACK framework of Mishra and Koehler (2006) suggests, ICT is a suitable means to promote the realization of alternative approaches to Mathematics, such as the realistic approach (Widjaja & Heck, 2003, p. 3). In their study which focused on the applicability of ICT-supported lessons, based on a RME approach, Widjaja and Heck (2003) reported that learners were both positive towards the use of ICT in lessons before and after implementing different ICT related tasks. Not only did learners’ performance improve in this study, but 77% of the group agreed or strongly agreed that doing activities using a computer was interesting and exciting and looked forward to making use of ICT in their next Mathematics lessons.

A study which explores teachers’ views on Mathematics education and the role of technology therein, and was guided by RME principles, reveals that teachers see technology as a means to stimulate interaction in the class, a key principle in RME (Drijvers et al., 2010a, p. 222). The study also revealed that teachers see technology as an effective means to achieve their teaching goal in Mathematics; they believe that ICT could help learners to develop understanding; and that technology is a suitable and useful means to provide scaffolding for learners with mid-ability who benefit from clear demonstrations and explanations in a structured manner (Drijvers et al., 2010a, p. 223).

A literature study to explore the existing body of knowledge with regard to the adoption of a RME approach, facilitated by technology to enhance teaching practice, was conducted. A systematic literature review was performed to not only limit bias (Petticrew & Roberts, 2006, p. 9), but also to summarise the existing evidence relating to the topic, to identify any gaps in current research to suggest possible areas for further investigation and to provide an appropriate background to position new research (Kitchenham, 2004, p. 2). Although not a common feature, systematic literature reviews have been used in the social sciences for many decades and are increasingly used to not only direct new research, but to support practice and policy (Petticrew & Roberts, 2006, p. 23).
The systematic literature review was done with the aid of the databases Scopus, EBSCOHost, Web of Science, Science Direct, MathSciNet, and Google Scholar. Various combinations of the following keywords were used to perform the searches: realistic* or RME, teach* or learn* or educat*, math*, tech* or ict or educat* tech*.

1.4 Research Questions

The study aimed to address the following main research question: What are the guidelines for the effective use of technology in implementing the RME approach in teaching practice? In order to effectively answer this research question, two sub-questions were also posed to gain insight on the main question. These questions were:
1. How can the use of the RME approach, facilitated by technology, enhance teaching practice?
2. What support needs do teachers have in order to effectively implement the RME approach in their teaching practice?

1.5 Purpose of the Study

The purpose of the study was to:
- Develop an understanding of how the RME approach, facilitated by technology, can enhance teaching practice;
- Establish support needs of teachers in order to effectively implement the RME approach in their teaching practice;
- Develop guidelines for the effective use of technology in implementing the RME approach in teaching practice.

1.6 Research Design and Methodology

Each researcher brings with him or her certain beliefs and philosophical assumptions to their research, which are instilled in them through different influences (Creswell, 2013, p. 15). Philosophical ideas are often hidden in research, yet they still influence research practice. A worldview or paradigm is a researcher’s orientation about the world and the nature of research (Creswell, 2009, p. 5). The significance of a paradigm is that it gives meaning to the world as we see it. The selected paradigm for this research was the interpretive paradigm. From an interpretive perspective, the focus is on describing, understanding or interpreting an experience (Merriam, 2009, p. 11).
Creswell (2013, p. 15) suggests that a qualitative researcher highlights the importance of understanding these beliefs and assumptions and also actively writes about them in a study, and this I have duly done in the study. The interpretive paradigm is “characterised by a concern for the individual” and aims to understand the “subjective world of human experience” (Cohen, Manion, & Morrison, 2011, p. 17). Interpretive approaches start with individuals and aim to understand those individuals’ interpretation of the world around them (Cohen et al., 2011, p. 18). Interpretive research is the most common type of qualitative research and works from the premise that reality is socially constructed; and that there is no single observable reality, but rather multiple realities (Merriam & Tisdell, 2016, p. 9).

Researchers with interpretivist goals describe and attempt to explain the meaning or implications of phenomena related to educational factors such as teaching, learning, performance, assessment and social interaction (McKenney & Reeves, 2012, p. 29). Design experiments aim to support the composition of an empirically grounded local instruction theory. They also aim to place classroom events in a broader context and serve as the context for the development of theoretical frameworks that entail new scientific categories, which can be useful in generating, selecting and assessing design alternatives. The interpretive framework serves as an innovation for interpreting classroom discourse and communication, and also shows what norms to aim for to make the design experiment successful (Gravemeijer & Cobb, 2013, p. 80). The interpretive framework has a dual purpose: it acts as a lens for making sense of what is happening in a real world setting, and acts as a guideline for instructional design. It also offers guidelines on the characteristics of the classroom culture (Gravemeijer & Cobb, 2013, p. 89).

Qualitative research is a “situated activity that locates the observer in the world” and consists of interpretive practices that make the world visible (Denzin & Lincoln, 2011, p. 6). The qualitative researcher studies “things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them” (Denzin & Lincoln, 2011, p. 6). Merriam and Tisdell (2016, p. 15) point out that qualitative researchers are concerned with “understanding the meaning people have constructed; that is, how people make sense of their world and the experiences they have in the world.” Qualitative researchers are concerned with “the meanings people attach to things in their lives” and identify with the people they study so as to understand how they see things (Taylor & Bogdan, 1998, p. 7).

As was the case in this study, various other qualitative studies including those of Baumann et al. (2013, p. 25); Juuti and Lavonen (2013, p. 49); Nathans and Revelle (2013, p. 164), have made use of a design-based research approach. Educational design-based research is an innovative and promising approach in which the iterative progression of solutions to complex problems provides the backdrop for scientific investigation (McKenney & Reeves, 2014, p. 131). Researchers who work with design-based research not only attempt to solve significant real world problems, but seek to unfold new knowledge (McKenney & Reeves, 2014, p. 131). The common features of design-based
research include the following: theories on learning and teaching are produced; it is interventionist; it is iterative and takes place in real life settings (Barab & Squire, 2004, p. 2). Design-based research is concerned with using design to develop models of how people think, know, act and learn; as well as to uncover, explore and confirm theoretical relationships (Barab & Squire, 2004, p. 5).

1.7 Population and Participant Selection

The teacher-students that participated in this research were enrolled at the North-West University (NWU) Potchefstroom Campus in South Africa. The NWU has three campuses across South Africa: Mafikeng Campus, Potchefstroom Campus and Vaal Triangle Campus. The Unit for Open Distance Learning (UODL) is situated on the Potchefstroom Campus and services in the region of 30 000 students who are registered to study various courses through distance education. The majority of these students are in the Faculty of Education Sciences, and are teachers who are under- or unqualified and who want to upgrade their qualifications (Pienaar, 2016, p. 1). The UODL has 65 study centres in South Africa, Namibia and other countries. Lectures are broadcast to these centres where students can attend contact classes and have access to a mini-library equipped with computers with Internet access (Spamer, 2016, p. 1). Figure 1.2 illustrates the location of the various study centres in South Africa and Namibia.

![Figure 1.2: Distribution of NWU Study Centres across South Africa and Namibia](image-url)
Many of the teacher-students are from disadvantaged schools and are women (Kok, 2009). They live in areas that range from deep rural areas where there is often no electricity or running water to fully urbanized communities such as Johannesburg and Cape Town. Many teacher-students work in classrooms that are often not well-equipped and teach large groups of learners (more than forty in a classroom). Despite these circumstances, the teacher-students still have the desire to improve their qualifications.

Stratified purposive sampling entails that participants are selected according to preselected criteria relevant to the research question (Nieuwenhuis, 2010c, p. 79). I selected this sampling method because I wanted to understand what needs in-service Mathematics teachers had in terms of making Mathematics more realistic for their learners. In this study, I selected participants from a group of in-service teachers enrolled for the BEd Honours post-graduate degree in Mathematics education at the NWU, which is delivered by both the dual face to face and ODL mode. The criteria for selection were as follows:

(i) teacher-students enrolled at the NWU for the BEd Honours degree through either face to face or ODL mode
(ii) teacher-students who attended contact classes for the degree in question
(iii) teacher-students who are currently teaching Mathematics in any Phase
(iv) male and female teachers at various schools.

1.8 Methods of Data Generation

After the systematic literature review had been completed, I designed an interview schedule for a semi-structured interview with teacher-students in order to establish what needs they had in relation to making the Mathematics content more realistic for their learners. Mathematics teaching that is related to real life has proved to enhance learners’ understanding (Fauzan et al., 2013, p. 174) and can stimulate and address alternative conceptions of learners (Barnes, 2004, p. 63). I facilitated the semi-structured interviews with four teacher-students. When I coded and categorised the data, using ATLAS.ti™, I was able to determine two important aspects in this study: what areas of the curriculum were problematic to the teacher-students and also to their learners; and what areas they found difficult to present in a real life context. With the help of a programmer, I designed an application (app) to guide teacher-students in how to present mathematical content using the principles of RME. Teacher-students were given the opportunity to work with the app, and gave feedback at a follow-up focus group interview. These interviews were also coded with the aid of ATLAS.ti™.
1.9 Methods of Data Analysis

The data obtained through the interviews were transcribed and the documents were assigned to the Computer Assisted Qualitative Data Analysis Software (CAQDAS), ATLAS.ti™, where they were coded. ATLAS.ti™ offers a variety of tools to explore the phenomena concealed in the data. ATLAS.ti™ provided me with an environment in which to manage, compare, explore and reassemble meaning from the data in a systematic manner (Friese, 2014a, p. 10).

1.10 Ethical Aspects of this Research

The following ethical principles were applied throughout the project, namely that the participants were protected from any harm and the research data would at all times remain confidential (Fraenkel & Wallen, 2003, p. 57). The necessary ethics application form was completed and submitted to the North-West University's ethics committee, and permission was attained to commence the research. The ethical clearance number for this study is: NWU-HS-2014-0267. Participants were requested to complete a letter of consent, providing me with permission to continue with the project. The letter ensured participants that their participation was voluntary, their identity would remain anonymous, all information would be treated as confidential and that their decision whether to participate in the project or not, would not jeopardise their studies in any way.

1.11 Contribution of this Study

This contribution of this study would be to develop, implement and evaluate the use of the RME approach supported by technology, as presented to in-service teacher-students enrolled for a postgraduate degree in Mathematics education. The aim was to provide guidelines for the effective use of the RME approach, facilitated by technology, to enhance the usefulness of Mathematics in the classroom, and improve teaching and learning practice. The study contributed towards the subject area and discipline of Mathematics by providing insight into the needs of Mathematics teachers in terms of making Mathematics more realistic for their learners. The findings of this study could assist curriculum experts and lecturers in the designing and adaptation of study material that is more relevant for teaching practice. It could also assist teachers and learners by making the mathematical content more relevant and realistic for them. The study also produced guidelines as to how the RME approach could be successfully facilitated by technology to improve teaching and learning practice.

1.12 Clarification of Important Terminology

Table 1.2 presents the clarification of some important terminology used in the study.

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Table 1.2 presents the clarification of some important terminology used in the study.
<table>
<thead>
<tr>
<th>Term</th>
<th>Clarification of term</th>
</tr>
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<tbody>
<tr>
<td>Mathematics</td>
<td>Freudenthal (1968, p. 4) argues that Mathematics has proved indispensable for the understanding and the technological control of both the physical world and the social structure. Mathematics has been described by some as a static discipline developed abstractly, while others see it as a dynamic discipline constantly changing due to new discoveries (Dossey, 1992, p. 39). Other authors describe Mathematics as the science of pattern and order, which challenges the view that Mathematics is merely a discipline dominated by computation (Van de Walle, Karp, &amp; Bay-Williams, 2013, p. 13). Mathematics is also described as a human endeavour in which ordinary people construct concepts, discover relationships, invent methods, execute algorithms, communicate and solve problems posed by the real world (Cangelosi, 2003, p. 7).</td>
</tr>
<tr>
<td>Realistic Mathematics Education (RME)</td>
<td>Realistic Mathematics Education (RME) is rooted in the work of Freudenthal (1973). Freudenthal views Mathematics as a human activity of sense-making where learners should be given the opportunity to reinvent Mathematics by organising or mathematizing real world situations. The basic principles of RME view the learning of Mathematics as a progressive reorganisation of real world situations or mathematical processes (Cobb et al., 2008, p. 107).</td>
</tr>
<tr>
<td>Learning technology</td>
<td>Learning technology is defined as the application of technology for the enhancement of teaching, learning and assessment (Rist &amp; Hewer, 1996, p. 3). Learning technology is viewed as not only a technical skill or as a means of improving learning effectiveness, but also a way of shifting goals and processes of education (Law et al., 2008, p. 14).</td>
</tr>
<tr>
<td>Technology</td>
<td>Technology has the potential to promote generalisation and justification by enabling fast and accurate computation, collection and analysis of data (Goos, Galbraith, Renshaw, &amp; Geiger, 2003, p. 74). It is also able to provide learners with rich learning environments, which allows them to adopt a wide range of perspectives on complex issues and cater for individual differences (Sang, Valcke, van Braak, &amp; Tondeur, 2010, p. 103).</td>
</tr>
<tr>
<td>Student teacher</td>
<td>Student teacher refers to pre-service students who are studying in the field of education.</td>
</tr>
<tr>
<td>Teacher-student</td>
<td>Teacher-student refers to teachers, who are currently in the profession, but who are furthering their qualifications on a part-time basis, the mode of delivery could be either face-to-face or open-distance learning (ODL).</td>
</tr>
</tbody>
</table>
Chapter Two
Research Design and Methodology

2.1 Introduction

The literature offers various definitions for research. One such definition is that research is a step by step process of collecting and analysing information to increase our understanding of a topic or issue (Creswell, 2014, p. 17). Merriam and Tisdell (2016, p. 3) state that what most of these definitions have in common is the idea of “inquiring into, or investigating something in a systematic manner.” Research is important because it adds to our knowledge, it improves practice and it informs policy debates (Creswell, 2014, p. 18). Researchers bring their own beliefs and philosophical assumptions to their research projects. There is a close connection between the philosophy that researchers hold and how they advance to use a framework to encompass the investigation (Creswell, 2013, p. 15).

Educational research is important because it helps us in understanding educational processes, guides our decision making and can enhance classroom, school and system accountability (McMillan & Schumacher, 2014, p. 11). This research aims to produce guidelines for the effective facilitation of technology to facilitate Realistic Mathematics Education to enhance teaching practice.

This chapter in detail describes the choices I made during my research journey and it informs all subsequent chapters in terms of the world view of the researcher, the design and methodology for this study, choices regarding research strategies, intervention strategies and the consequent guidelines. Figure 2.1 illustrates the research design and methodology that has been used in this study.

The study is driven by the research question as discussed in § 1.4, namely: What are the guidelines for the effective use of technology in implementing the RME approach in teaching practice? The two sub-questions that were posed to gain insight on the main question were:
1. How can the use of the RME approach, facilitated by technology, enhance teaching practice?
2. What support needs do teachers have in order to effectively implement the RME approach in their teaching practice?
2.1 Main Research Question:
What are the guidelines for the effective use of technology in implementing the RME approach in teaching practice?

Sub-questions:
1. How can the use of the RME approach, facilitated by technology, enhance teaching practice?
2. What support needs do teachers have in order to effectively implement the RME approach in their teaching practice?

2.2 Worldview
Interpretivist

2.3 Research Design
Qualitative Phenomenology

2.4 Research Methodology
Qualitative design-based research

2.5 Ethical considerations

2.6 Systematic Literature Review

2.7 Aspects for Intervention

2.8 Qualitative Strategy
Needs analysis
- Participant selection Purposive
- Site selection Purposive
- Data generation method Individual interviews
- Data analysis ATLAS.ti™

2.9 Intervention strategy: Design of app

2.10 Qualitative Strategy
Perceptions about app
- Participant selection Purposive
- Site selection Purposive
- Data generation method Focus Group interview
- Data analysis ATLAS.ti™

Figure 2.1: Research Design and Methodology for this Study
2.2 Worldview of the Research

Social scientists have particular assumptions about the nature of the social world, and they approach their subject with this in mind. These assumptions are of an ontological, epistemological, human, and methodological nature (Burrell & Morgan, 1994, p. 1). Burrell and Morgan (1994, p. 2) refer to assumptions of an ontological nature as the very essence of the phenomena being investigated; assumptions of an epistemological nature as the “assumptions about the grounds of knowledge,” how one can understand the world and communicate this knowledge to others; and assumptions about human nature as the relationship between human beings and their environment. The three sets of assumptions directly impact the methodological nature. Different models of ontology, epistemology and human nature direct social scientists to different methodologies (Burrell & Morgan, 1994, p. 2).

As Merriam (2009, p. 8) and Creswell (2013, p. 19) aptly explain, there is little consistency regarding the philosophical foundations of qualitative research. As is typical of qualitative research, different authors make sense of the philosophical influences each in his or her own way. Various terms and descriptions are used such as: paradigms; philosophical assumptions; traditions and theoretical underpinnings; theoretical traditions and orientations; theoretical paradigms; worldviews and epistemology; and theoretical perspectives (Creswell, 2013, p. 19; Merriam, 2009, p. 8). In essence they are beliefs about ontology (the nature of reality), epistemology (what counts as knowledge and how knowledge claims are justified), axiology (the role of values in research) and methodology (the process of research) (Creswell, 2013, p. 20). These beliefs shape how the qualitative researcher views the world and acts in it (Denzin & Lincoln, 2013, p. 26). Berman and Smyth (2013, p. 6) suggest a model to illustrate the alignment of ontology, epistemology and methodology within a doctoral study.

Table 2.1 Pedagogical Model for the use of Conceptual Frameworks in a Doctoral Study (Berman & Smyth, 2013)

<table>
<thead>
<tr>
<th>WHAT ontology</th>
<th>HOW methodology</th>
<th>WHY epistemology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context for the research problem</td>
<td>Research theme(s)</td>
<td>New knowledge</td>
</tr>
<tr>
<td>Key concepts</td>
<td>Explicit research questions</td>
<td>New theorising</td>
</tr>
<tr>
<td>Relationships</td>
<td>Research design</td>
<td>Extent (limits) of generalising</td>
</tr>
<tr>
<td>Establishment of terminology and common language</td>
<td>Methodology (data gathering, organising, analysing, interpreting)</td>
<td>Implications for practice</td>
</tr>
<tr>
<td>Boundaries for conclusions and theorising</td>
<td>Validity (conceptual, practical ...)</td>
<td></td>
</tr>
</tbody>
</table>

They refer to these aspects as the what, why and how of research and represent the alignment of ontology, epistemology and methodology. The ontology, or what is being researched, refers to the reality of the context of the research problem; it must be clear and confined so that a solid foundation for shared meaning can be established (Berman & Smyth, 2013, p. 6). These ontological concerns are linked to the meaning of the research, or the epistemology (the why of the research). As new knowledge is generated from comprehensive abstract thinking, epistemological outcomes can be
produced which could have both theoretical and practical implications. The higher order thinking and conceptualisation of reality and knowledge and the specific epistemology guides the nature of the methodology (the how of the research) (Berman & Smyth, 2013, p. 6).

2.2.1 Ontology

In classical philosophy, ontology referred to the science of being; however, the meaning has evolved during the contemporary era (Given, 2008, p. 577). Ontology is in essence a form of questioning (Given, 2008, p. 580) and refers to the nature of reality and its characteristics (Creswell, 2013, p. 20; Ormston, Spencer, Barnard, & Snape, 2014, p. 2; Willis, Jost, & Nilakanta, 2007, p. 9). Different ontological perspectives reflect different prescriptions of what can be real and what cannot be real (Willis et al., 2007, p. 9). One’s beliefs about the nature of reality or ontology is an indication of one’s philosophical positioning (Merriam, 2009, p. 8), which means that different researchers, the individuals being studied as well as the readers of the qualitative study, embrace different realities (Creswell, 2013, p. 20). The aim of qualitative research is to report these multiple realities using varied evidence in themes where actual words of different individuals are used to present different perspectives (Creswell, 2013, p. 20).

2.2.2 Epistemology

Epistemology is an essential part of a philosophical study that “includes the sources and limits, rationality and justification of knowledge” (Given, 2008, p. 264). It refers to the nature of knowledge (Merriam, 2009, p. 8) and how it can be acquired (Ormston et al., 2014, p. 2); theories of knowledge and perceptions in science (Flick, 2014, p. 536); the relationship between the inquirer and the known (Denzin & Lincoln, 2013, p. 26) or otherwise phrased, as the nature of the relationship between the researcher and what can be known (Terre Blanche & Durrheim, 2006, p. 6). Epistemology is concerned with what we know about reality and how we get to know it (Willis et al., 2007, p. 10). When doing a qualitative study, the researcher tries to get as close as possible to the participants being studied in order to accumulate subjective evidence based on individual views (Creswell, 2013, p. 20). The subjective experiences of people create knowledge, which means that studies need to be conducted in the field, where participants live and work (Creswell, 2013, p. 20).

The interpretive paradigm is informed by a concern to understand the world as it is, and strives to explain the world within the participant’s frame of reference, rather than that of the observer (Burrell & Morgan, 1994, p. 28). Interpretive research starts out with the assumption that reality can only be accessed through social constructions like language, consciousness and shared meanings. Interpretive research is guided by a set of beliefs and emotions about the world and how it should be understood and studied (Denzin & Lincoln, 2011, p. 12). Interpretive studies attempt to understand phenomena through the meanings that people assign to them, and aim to offer a perspective of a
situation and analyse a situation to provide insight into the way in which a particular group of people make sense of their situation (Nieuwenhuis, 2010b, p. 60).

Burrell and Morgan (1994) have done extensive work relating to different approaches to social theory. They identify four paradigms for the analysis of social theory (Figure 2.2).

The sociology of radical change

Subjective

Radical humanist

Radical structuralist

Objective

The sociology of regulation

Interpretive

Functionalist

Figure 2.2: Four Paradigms for the Analysis of Social Theory (Burrell & Morgan, 1994, p. 22)

The four paradigms describe overlapping, but fundamentally different perspectives for analysing social phenomena (Burrell & Morgan, 1994, p. 23). These four paradigms represent four sets of basic assumptions in social theory, and they define four views of the social world based on different assumptions with regard to science and society (Burrell & Morgan, 1994, p. 24). When located in each different paradigm, the world is viewed in a particular way. The functionalist paradigm represents a perspective which approaches its subject matter from an objectivist point of view. It is rooted in the sociology of regulation. This paradigm is concerned with explaining the following issues: the status quo, social integration, solidarity, need satisfaction and actuality. These concerns are approached from an outlook that is realist, positivist, determinist and nomothetic. In general this paradigm provides rational explanations of social affairs; it is pragmatic in nature and is concerned with understanding society in a way which produces knowledge (Burrell & Morgan, 1994, pp. 25-26).

Since this study is rooted in the Interpretivist paradigm, this paradigm will be discussed in detail in § 2.2.3. The radical humanist paradigm is concerned with developing a sociology of radical change from a subjectivist point of view. It sees the social world from a nominalist, anti-positivist, voluntarist and ideographic perspective. In this paradigm social theorising is designed to critique the status quo.
In this paradigm, the greatest emphasis is based on radical change, modes of domination, emancipation, deprivation and potentiality (Burrell & Morgan, 1994, p. 32).

The radical structuralist paradigm promotes a sociology of fundamental change. It is dedicated not only to radical change, but also to emancipation and potentiality, and emphasises structural conflict, modes of domination, contradiction and deprivation. This paradigm approaches these issues from a realist, positivist, determinist and nomothetic perspective. The rational structuralist focuses on structural relationships within a realist social world (Burrell & Morgan, 1994, p. 34).

2.2.3 Interpretivist Paradigm

The interpretivist paradigm is driven by a concern to understand the world as it is, to understand the fundamental nature of the social world. It strives to explore the realm of individual consciousness and subjectivity within the participant’s frame of reference. The interpretivist paradigm’s approach to social science is nominalist, anti-positivist, voluntarist and ideographic. It views the social world as a developing social process, created by the concerned individuals (Burrell & Morgan, 1994, p. 28). Interpretivist theorists strive to understand the basis and source of social reality. Their stance is backed by the assumption that the world of human affairs is cohesive, ordered and integrated. Issues like conflict, domination, contradiction, potentiality and change do not feature in their framework. Their concern is with understanding the social world “as it is” and is involved with issues relating to the nature of social order (Burrell & Morgan, 1994, p. 31).

Interpretivist research is guided by specific beliefs and feelings about the world and how it should be understood and studied (Denzin & Lincoln, 2013). For interpretivists, the meaning of the world for the person or group being studied is critically important to good research in social sciences (Willis et al., 2007, p. 6). Denzin and Lincoln (2013, p. 27) categorise the interpretivist paradigm as positivist and postpositivist, constructivist-interpretivist, critical and feminist-poststructural. A core belief of this paradigm is that the reality we know is socially constructed (Merriam & Tisdell, 2016, p. 9; Willis et al., 2007, p. 95), which implies that researchers only have access to a socially constructed reality (Willis et al., 2007, p. 97). This serves as a justification as to why social constructivism is also known as interpretivism (Creswell, 2013, p. 24), and that there is no single observable reality (Merriam & Tisdell, 2016, p. 9). Understanding the context in which the research takes place is crucial to the interpretation of the data that are gathered (Willis et al., 2007, p. 98).

The purpose of interpretivist research is to understand a particular situation, and not to discover universal laws (Willis et al., 2007, p. 111). There is not a so-called “correct way” of viewing a particular situation, it is rather an understanding of multiple perspectives on the topic (Willis et al., 2007, p. 113). Individuals develop subjective meanings, which are directed towards certain objects, of their experiences. The meanings are many and diverse, which means that the researcher needs to seek the complexity of the views, rather than limit the meaning into a few selected categories (Creswell,
This kind of research addresses the process of interaction between individuals. The contexts in which people live and work need to be considered when attempting to understand the historical and cultural setting of the participant. The researchers' own backgrounds, such as their own personal, cultural and historical experiences, shape the way in which they interpret the research (Creswell, 2013, p. 25). Interpretivists do not consider any form of research to be completely objective and tend to prefer data sources that are close to the point of application because context is so important in the interpretation of data (Willis et al., 2007, p. 111). Qualitative research is most often located within an interpretive paradigm, which assumes that reality is socially constructed and that there are numerous realities or interpretations of a single event (Merriam, 2009, p. 8).

2.3 Research Design: Qualitative Phenomenology

Research design refers to the decisions about how research is conceptualised, the conducting of a research project and the type of contribution the research is envisioned to make to the body of knowledge (Given, 2008, p. 761). The process in which a research design is developed entails three related components, namely the theoretical, methodological and ethical considerations, which all shape the design and what the research is aiming to achieve (Given, 2008, p. 761). A research design describes a flexible course of action that links theoretical paradigms to two aspects, namely strategies of inquiry and methods of collecting empirical data (Denzin & Lincoln, 2008, p. 33). It also positions the reader in the empirical world and connects him or her to specific locations, persons, groups, organisations and forms of relevant interpretive material such as documents and archives (Denzin & Lincoln, 2008, p. 34).

2.3.1 Research Approach: Qualitative Design

One of the most generic definitions for qualitative research is offered by Denzin and Lincoln (2008, p. 4), namely that it is “a situated activity that locates the observer in the world.” Qualitative research can be used to explore a problem or issue, to empower individuals to share their experiences, and/or to develop theories when partial or inadequate theories need to be further explored (Creswell, 2013, p. 48). It aims to thoroughly describe “life-worlds” from the participants’ points of view and strives to create a better understanding of social realities (Flick, von Kardoff, & Steinke, 2010, p. 3). It involves the collection of different kinds of empirical material that describes moments and meanings in individuals’ lives (Denzin & Lincoln, 2013, p. 7).

Qualitative researchers are concerned with understanding how people interpret their experiences, how they create their worlds and what meaning they ascribe to their experiences (Merriam & Tisdell, 2016, p. 6). They accentuate the importance of both understanding and writing about the beliefs and theories that inform their research (Creswell, 2013, p. 15); they collect data in a natural setting and are sensitive to the people and places that are being studied. The final report presents “the voices of the
participants, the reflexivity of the researcher, a complex description and interpretation of the problem, and its contribution to the literature” (Creswell, 2013, p. 44). Creswell (2013, p. 44) emphasises the process of research, namely the philosophical assumptions, interpretive lens, and the procedure for studying human or social problems.

Creswell (2013, p. 45) describes an extensive list of characteristics of qualitative research, which include the following aspects: the research is conducted in a natural setting; the researcher acts as a key instrument in data collection; it involves the use of multiple methods; complex reasoning through inductive and deductive logic is used; it focuses on participants’ perspectives and meanings; it is situated within the context of the participants; it involves an emergent and evolving design; it is reflective and interpretive and sensitive to the researcher’s background; and it presents a holistic, complex picture of the issue being studied. Flick (2014, p. 14) narrows this list down to the following essential features, namely: the correct choice of appropriate methods and theories; recognising the perspectives of the participants and their diversity; the researchers’ reflections on the research (reflexivity); and the variety of approaches and methods in qualitative research. Qualitative research should be used when an issue needs to be explored and we need a detailed understanding of the issue, and to develop theories (Creswell, 2013, p. 47).

Qualitative research is concerned with understanding the meaning people have constructed, which means it has to do with how people make sense of their world and the experiences they have in the world (Merriam, 2009, p. 13). Although various characteristics have been explored to understand qualitative research, Merriam (2009, p. 14) highlights four characteristics that stand out as most important in understanding qualitative research. These are: the focus is on the process, understanding and meaning; the researcher is the main instrument in collecting and analysing the data; the process is inductive, and the product is richly descriptive.

Nieuwenhuis (2010b, p. 50) refers to qualitative research as research that attempts to collect rich descriptive data about a particular phenomenon or context in order to develop an understanding of what is being observed. The focus is on how individuals and groups view and understand the world and construct meaning from their experiences. Qualitative research is concerned with understanding the processes and the social and cultural contexts which underlie behavioural patterns. It studies people or systems by interacting with and observing the participants in their natural environment, the focus being on their interpretations and meanings. The emphasis of qualitative research is on the quality and depth of information, rather than on the scope or the breadth of the information. (Nieuwenhuis, 2010b, p. 51).

The most important concern is therefore to understand the phenomena being researched from the perspective of the participant rather than the researcher. In order to effectively understand the phenomena, it makes most sense that the researcher acts as the primary instrument to collect and analyse the data, since he or she could expand his or her understanding through verbal and non-
verbal communication, by processing data immediately, summarizing material, making certain that interpretation is accurate by checking with participants and exploring responses that were unusual or unexpected (Merriam, 2009, p. 15). Qualitative research is concerned with gathering data to build concepts, hypotheses or theories instead of deductively testing hypotheses. The product of qualitative research is abundantly descriptive because words and pictures rather than numbers are used to express what has been discovered about the phenomenon (Merriam, 2009, p. 16).

2.3.2 Qualitative Approach to Inquiry: Phenomenology

Phenomenology emphasises the subjectivity and relativity of reality and highlights the need to understand how humans view themselves and the world around them (Willis et al., 2007, p. 53). It is the study of the way in which people perceive the world, rather than trying to learn what the world is. The focus is on understanding from the perspective of the person(s) being studied (Willis et al., 2007, p. 107). Phenomenology focuses on the lived experience and how being subjected to an experience is converted into consciousness (Merriam & Tisdell, 2016, p. 26). The task of the phenomenologist is to portray the quintessence of the experience, which can often be an intense human experience (Merriam & Tisdell, 2016, p. 26).

A phenomenological study describes the mutual meaning for a number of individuals, of their lived experiences of a concept or a phenomenon, the focus being on the description of what participants have in common as a particular phenomenon is experienced (Creswell, 2013, p. 76). A study such as this produces a “composite description that presents the ‘essence’ of the phenomenon” (Creswell, 2013, p. 82). It refers to the study of the perceptions of the person being studied (Willis et al., 2007, p. 108). Phenomenology serves to reduce an individual experience with a phenomenon to an account of the universal principle. It is in many ways the study of consciousness (Willis et al., 2007, p. 172) and is ideally used in the social sciences (Creswell, 2013, p. 77). Two types of phenomenology exist, namely hermeneutic phenomenology; and empirical, transcendental, or psychological phenomenology. Hermeneutical phenomenology is research that is directed towards lived experiences where the transcripts of life are interpreted (Creswell, 2013, p. 79).

2.4 Research Methodology: Qualitative Design-based Research

A researcher’s philosophical stance and paradigm informs the methodology used, including the research design and techniques used to gather, analyse and interpret the data (Creswell & Clark, 2011, p. 38). Methodology refers to the way in which we approach problems and look for answers (Taylor & Bogdan, 1998, p. 3); how we know the world or gain knowledge of it (Denzin & Lincoln, 2011, p. 12); the process of how we look for new knowledge (Lincoln, Lynham, & Guba, 2013, p. 213). Methodology is interwoven with and develops from the nature of a particular discipline and perspective (Lincoln et al., 2013, p. 200). The methodology of qualitative research is considered to be inductive,
emerging and guided by the researcher’s experience in collecting and analysing the data (Creswell, 2013, p. 22).

Qualitative research served as a suitable approach within design-based research methodology in a number of studies (Guler & Altun, 2010, p. 118; Gunn & Lefoe, 2013, p. 45; Nathans & Revelle, 2013, p. 164). Design-based research is a suitable approach for a short-term project such as a PhD provided the relevant phases are followed and the required outcomes are achieved (Pool & Laubscher, 2016, p. 10). It necessitates a significant literature review and theory generation and makes use of different data analysis and collection methods which are used in quantitative or qualitative research, and is considered to be an effective and efficient approach to investigate processes in educational settings (Wang & Hannafin, 2005, p. 6). Design-based research is considered to be a series of approaches set on producing new theories, artefacts and practices that can have an impact on teaching and learning (Barab & Squire, 2004, p. 2).

The design-based research approach is rooted in two approaches in the teaching of Mathematics, namely the socio-constructivist approach and the RME approach (Gravemeijer & Cobb, 2013, p. 74). The theory of RME offers design heuristics and also functions as an interpretivist framework to interpret student activity in the learning of Mathematics (Gravemeijer & Cobb, 2013, p. 89). Plomp (2007, p. 13) describes educational design-based research as “the systematic study of designing, developing and evaluating educational interventions (such as programmes, teaching-learning strategies and materials, products and systems) as solutions for complex problems in educational practice, which also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them.” Design-based research in education is described as research in which the design of materials such as computer tools or learning tasks forms an essential part of the research. The design of learning environments is interwoven with the developing of theory (Bakker & van Eerde, 2012, p. 2). Design-based research is defined by the goals of those who pursue it, rather than by its methods (McKenney & Reeves, 2012, p. 28). Plomp (2007, p. 11) distinguishes between different research functions which characterise design-based research, namely to describe, to compare, to evaluate, to explain or to predict, to design and develop. The focus of design-based research is on understanding (Gravemeijer & Cobb, 2013, p. 74).

Wang and Hannafin (2005, p. 6) define design-based research as a systematic and flexible methodology aimed at improving educational practices through iterative analysis, design, development and implementation. This collaboration takes place between researchers and practitioners and real world settings. Design-based research is a series of approaches where the aim is to produce new theories, artefacts and practices that can impact teaching and learning (Barab & Squire, 2004, p. 2). It is further described as being a means to capture social interaction, and is considered to involve flexible design revision (Barab & Squire, 2004, p. 3). Amiel and Reeves (2008, p. 35) claim that, due to the intentions and lifecycle proposed by a design-based framework, it is in a position to address the complexities that are characterised by educational technology research. Researchers not only design
research processes, but also design and implement interventions systematically to improve designs and advance pragmatic and theoretic aims (Wang & Hannafin, 2005, p. 6).

The research process in design-based research is cyclical in nature. Activities involving analysis, design, evaluation and revision are iterated (Plomp, 2007, p. 13). Authors represent this process of design-based research in different ways, one such representation by Amiel and Reeves (2008, p. 34) (Figure 2.3), is as follows:

![Figure 2.3 The Process of Design-based Research (Amiel & Reeves, 2008, p. 34)](image1)

Another illustration is presented by McKenney (2001, p. 12) and is presented in Figure 2.4.

![Figure 2.4 Illustration of the CASCADE-SEA Study by McKenney (2001, p. 12)](image2)

As illustrated in Figure 2.4, McKenney (2001, p. 12) indicates that design-based research features three main phases, namely needs or contextual analysis, design or formative evaluation of the prototype tools and a summative assessment of the final product. These phases are represented on
the horizontal axis. Each phase consists of a number of cycles of activities which involve different groups of participants, which could include experts or users. The vertical axis represents the number of participants in relation to the phases of the research. Although authors represent the design-research process in different ways, there are essentially three main stages in the process: preliminary research, prototyping and assessment. Throughout these stages researchers will perform systematic reflection and documentation to produce the required scientific harvest in the form of theories or design principles (Plomp, 2007, p. 15). An adapted version of the illustration presented by McKenney (2001, p. 12), specific to this study, will be discussed later in this section.

McKenney and Reeves (2012, p. 76) build on models such as these, and represent a visual model (Figure 2.5) that depicts the overall process from the point of view of the researcher.

![Generic Model for Conducting Design Research in Education](image)

**Figure 2.5** Generic Model for Conducting Design Research in Education (McKenney & Reeves, 2012, p. 77)

The three core phases of their model are: analysis and exploration; design and construction and evaluation and reflection, followed closely by a fourth output phase which includes maturing intervention and theoretical understanding. The iterative nature of the process is emphasised by the arrows between the different components. As is emphasised by various specialists on design-based research, McKenney and Reeves (2012, p. 77) also accentuate both the iterative and flexible nature of design-based research. The process is iterative because results from certain elements lead into others on a continual basis, and flexible because many different routes can be followed. The output that is produced in such a process is both theoretical and practical. The implementation and spread referred to in the figure indicate the increasing interaction with practice (McKenney & Reeves, 2012, p. 77).

The process of design-based research starts with an analysis of the problem that exists in educational practice. In this step expertise is pursued in the form of a literature review to establish theoretical contributions that help to understand the problem and context. The literature also helps to develop a scientifically related approach for the study (McKenney & Reeves, 2012, p. 78). Once a solid understanding of the problem and context has been established, an unrestricted exploration can take place in which similar problems and their solutions are explored (McKenney & Reeves, 2012, p. 79).
In this study, the poor Mathematics results in South Africa in particular, and the influence of a teaching approach on learners’ achievement in Mathematics, created the need to investigate the effect of using technology to implement the principles of the RME approach in teaching practice. In this study, the systematic literature review (§ 2.6) which focused on the literature relating to RME, Mathematics education and ICT, explored current work on existing design principles and technological innovations. This first step was further explored by doing a needs analysis of the teacher-students (§ 2.8) to establish which areas of the curriculum they found problematic to teach and also in which sections they had difficulty applying the principles of RME.

The second step in the process of design-based research is to develop solutions informed by existing design principles and innovations in technology (Amiel & Reeves, 2008, p. 34). In this stage, an articulate process is followed and recorded in which a tentative solution to the problem is sought (McKenney & Reeves, 2012, p. 79). Here a conceptual model is created—during design, solutions to the problem are “generated, explored and considered” and eventually charted (McKenney & Reeves, 2012, p. 79). It is important here as well that the guidelines for the actual building of solutions are defined. Construction is where the ideas of the design stage are applied to manufacture a potential solution (McKenney & Reeves, 2012, p. 79). In this study, the design phase was realised by the development of a mobile application tool that aimed to address the needs expressed by the teacher-students. A detailed description of the design process is presented in Chapter Five.

The third step in the process of design-based research is that of evaluation and reflection where iterative cycles of refinement of solutions in practice are performed (Amiel & Reeves, 2008, p. 34). Evaluation refers to the empirical testing of the design or constructed intervention. Reflection comprises “active and thoughtful consideration of what has come together in both research and development” in order to produce theoretical understanding (McKenney & Reeves, 2012, p. 80). As one reassesses and reflects upon the data, new designs are created and employed to produce an ongoing cycle of design-reflection-design. In this study the evaluation and reflection took place throughout the design process. Various prototypes of the app were created and tested by novices, experts in the field of Mathematics education, an expert in the field of RME as well as the design team, which consisted of an expert programmer who is experienced in the design of mobile applications; my promoter who is an expert in the field of using technology in teaching and learning; my co-promoter, an expert in Mathematics and Mathematics education; and myself, who took on the role of content specialist.

In the output phase, design principles are produced and the implementation of solutions are enhanced (Amiel & Reeves, 2008, p. 34). The ultimate outcome of design-based research is to produce a set of design principles which are empirically derived and richly described (Amiel & Reeves, 2008, p. 35). In Figure 2.5, McKenney and Reeves (2012, p. 80) depict two main outputs from design-based research, namely maturing interventions, which contribute to practice; and theoretical understanding, which is
produced through (usually several) micro- and meso-cycles of design-based research. In this study the design-based research produced guidelines for the effective use of technology in implementing the RME approach. The guidelines are presented in detail in Chapter Seven. These guidelines contribute to practice by presenting ideas and suggestions for using technology to reinforce the principles of RME in teaching practice.

For the purposes of this study, it was necessary to adapt the illustration by McKenney (2001, p. 12) to suit the design-based process that was followed. Figure 2.6 presents this adapted illustration.

![The Design-based Research Process Specific to this Study, adapted from McKenney (2001, p. 12)](image)

**Figure 2.6:** The Design-based Research Process Specific to this Study, adapted from McKenney (2001, p. 12)

In this study, the three phases as suggested by McKenney (2001, p. 12) were also relevant: needs and content analysis; design, development and formative evaluation; and semi-summative evaluation. Time is represented on the horizontal axis and the phases are also represented on the horizontal axis. The phases entailed the following activities: a systematic literature review in which concepts were validated; a needs analysis of the teacher-students’ needs relating to their teaching practice; the development of three different prototypes of a mobile app; a final evaluation of the mobile app; and finally guidelines for the effective use of technology in implementing the RME approach. On the vertical axis, the number of participants, which include users and experts, are represented. The cycles had varying numbers of participants. This is illustrated in Table 2.2.
<table>
<thead>
<tr>
<th>Cycle</th>
<th>Participants</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature review and concept validation</td>
<td>Myself, Promoter, Assistant promoter, Expert in Mathematics education and Systematic Literature Reviews</td>
<td>4</td>
</tr>
<tr>
<td>Needs analysis</td>
<td>Myself, Promoter, Assistant Promoter, four Participants, Two Experts in Mathematics education</td>
<td>9</td>
</tr>
<tr>
<td>Prototype 1</td>
<td>Myself, Promoter, Assistant Promoter, Expert Programmer</td>
<td>4</td>
</tr>
<tr>
<td>Prototype 2</td>
<td>Myself, Promoter, Assistant Promoter, Expert Programmer</td>
<td>4</td>
</tr>
<tr>
<td>Prototype 3</td>
<td>Myself, Promoter, Assistant Promoter, Expert Programmer, Two Experts in Mathematics education, three Novices</td>
<td>9</td>
</tr>
<tr>
<td>Final evaluation</td>
<td>Myself, Promoter, Assistant Promoter, Expert Programmer, four Participants</td>
<td>8</td>
</tr>
<tr>
<td>Guidelines</td>
<td>Myself, Promoter, Assistant Promoter</td>
<td>3</td>
</tr>
</tbody>
</table>

The emphasis on design-based research should be on the premise that the researcher should generate evidence-based claims about learning that addresses theoretical issues and generating theoretical knowledge in the field, rather than on showing that a particular design works (Barab & Squire, 2004, p. 6). This study aimed to determine what support needs in-service teacher-students had with regard to teaching using the RME approach, and it intended to yield guidelines for the effective use of technology in implementing the RME approach, thereby generating theoretically relevant knowledge to the body of scholarship.

One of the characteristics of design-based research is that it is interventionist, which means that the goal thereof is to design interventions in a real world setting, thus building a stronger connection between educational research and real world problems (Amiel & Reeves, 2008, p. 34; Joseph, 2004, p. 235; Plomp, 2007, p. 15). Other characteristics include: it is iterative—cycles of analysis, design and development, evaluation and revision take place; it is process oriented—the emphasis is on understanding and improving interventions. Additionally it is utility oriented—the value of a design is partly measured by how practical it is for users in real contexts; it is theory oriented—the design is partially based on a conceptual framework and theoretical proposals, and the evaluation of the prototypes in the intervention contribute to building theory. Added to that the involvement of practitioners is important—the active collaboration with and participation of practitioners increase the chances that the intervention is relevant and practical (Barab & Squire, 2004, p. 2; Plomp, 2013, p. 20).

This study was interventionist in that the interventions were not only designed in the real world setting of the Mathematics classroom, but the content that was designed was focused specifically on the real life application of Mathematics. The process was iterative in that a number of prototypes of the app were created and tested by novices and experts. The design of the intervention was grounded in the theory of RME. The five characteristics of RME were adhered to and the three principles of RME formed the foundation of the design. Each prototype was grounded in guided reinvention, focused on the use of models and adhered to the principle of didactical phenomenology. The experts who tested the app as well as the participants in the research played the role of practitioners. The experts were
all actively working in the field of Mathematics education, and IT education at a higher education institution (HEI), and dealt with Mathematics and technology in education on a daily basis. The participants were actively involved in Mathematics education at secondary school level. Following their needs analysis and opinions of the use of the RME approach in teaching Mathematics aided by technology, a suitable and appropriate intervention, in the form of the app, was designed to assist them in their teaching practice. The relevance of this intervention is discussed in detail in Chapter Six.

Design-based research is said to have a dual purpose (Plomp, 2013, p. 22), namely to develop prototypical products (curriculum documents and materials) along with experimental evidence of their quality; and to generate methodological directions for the design and evaluation of such products (Fauzan et al., 2013, p. 163). In developmental studies, not only should the research based intervention be functional and effective in addressing the solutions to the complex problem, but it should also contribute to the body of knowledge in the field as well, typically in the form of re-usable guidelines for addressing educational problems (Barab & Squire, 2004, p. 5; Plomp, 2013, p. 22). This links closely to the characteristic of theory orientation as discussed above.

Plomp (2013, p. 22) distinguishes between three types of design-based studies, namely developmental studies, validation studies and implementation studies. In developmental studies, the foundation is the identification of educational problems in which there are few validated principles available to structure and support the design and development activities (Plomp, 2013, p. 22). A characteristic of a developmental study is that the study is informed by prior research through a review of the literature. Researchers, together with practitioners, design and develop feasible and effective interventions by studying consecutive versions of the interventions in the relevant contexts. The final stage of a developmental study in design-based research is when a period of reflection follows where the researcher and practitioner reflect on the research process in order to produce design principles for developing innovative interventions which are significant for educational practice (Plomp, 2013, p. 22).

In validation studies the focus is on designing learning trajectories or environments in order to develop and validate theories about learning. The research goal is to develop or validate theory and it also has a dual purpose, namely to design learning environments with the purpose to validate design principles and to develop and validate theories about learning and learning environments (Plomp, 2013, p. 23). In such studies, researchers work in natural settings such as the classroom, rather than controlled settings (Plomp, 2013, p. 23).

Gravemeijer and Cobb (2013) distinguish between three phases in validation studies: preparing for the experiment; designing the experiment; and retrospective analysis. These phases are similar to those in developmental studies (Plomp, 2013, p. 26). In practice, it is possible that the design-based research may combine a developmental and validation study. Plomp (2013, p. 26) uses the work of Fauzan et al. (2013) as such an example. This research involved the development of a geometry
course based on the RME principles (developmental study) and also investigated the validity of design principles in a different context (validation study).

The findings in design-based research cannot be generalised to a larger universe. The researcher should try to generalise the design principles to form part of a broader theory. In order to do this, the design principles must be tested through a number of repetitions in various contexts (Plomp, 2013, p. 34).

2.5 Ethical Considerations

Given (2008, p. 273) describes ethics as “the part of human philosophy concerned with appropriate conduct and virtuous living.” Because qualitative research revolves around human endeavours, it is viewed by scholars as moral ethical endeavours. The ethical principles as suggested by Christians (2008, p. 192), namely informed consent; free of deception; privacy and confidentiality; and accuracy, were applied throughout the project. The necessary ethical application was completed and submitted to the North-West University’s ethical committee, and permission was obtained to commence the research. The ethical clearance number is: NWU-HS-2014-0267 (Addendum 2.1). The participants were provided with a letter describing their potential role in the research, which spelled out exactly what would be expected of them in the project. They were requested to complete a letter of consent, providing me with consent to continue with the project. This letter (Addendum 2.2) ensured the participants that participation was voluntary, that they were free to withdraw from the project at any time, that withdrawal would not jeopardise their studies in any way, and that all information would be treated as confidential. Names were not required at any point during the data generation which ensured that the participants remained anonymous.

2.6 Qualitative Systematic Literature Review

Kitchenham (2004, p. 1) defines a systematic literature review as “a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest.” Systematic literature reviews also serve as a “method of making sense of large bodies of information, and a means of contributing to the answers to questions about what works and what does not” (Petticrew & Roberts, 2006, p. 2). They are also a method of mapping out areas of uncertainty, and can indicate where new studies are necessary (Petticrew & Roberts, 2006, p. 2). Systematic literature reviews are used in a variety of fields including medicine, health care, social policy and education (Briner & Denyer, 2012, p. 1).

The most common reasons for performing a systematic literature review is: to summarise the existing evidence concerning a treatment or technology; to identify any gaps in the existing research; to
provide a framework in which to position new research; to examine the extent to which hypotheses are supported or contradicted by empirical evidence; or to assist in the generation of new hypotheses (Kitchenham, 2004, p. 1).

One of the advantages of doing a systematic literature review is that it provides information about the effects of a phenomenon across a wide range of settings (Kitchenham, 2004, p. 2). Systematic literature reviews are increasingly replacing traditional narrative reviews because they attempt to bring the same level of rigour to reviewing evidence as should be present in producing the evidence (Hemingway & Brereton, 2009, p. 1). Systematic literature reviews are suitable ways of examining quantitative or qualitative evidence (Hemingway & Brereton, 2009, p. 1).

Systematic literature reviews should adhere to a number of core principles. They should be: systematic and organised, transparent, replicable and updatable. They should also be able to synthesise and summarise the evidence relating to the research question (Briner & Denyer, 2012, p. 3). Important features that differentiate between a systematic literature review and a traditional literature review are: systematic reviews start by defining a review protocol that specifies the research question being addressed as well as the methods that will be used to do the review; systematic reviews are based on a defined search strategy with the purpose of detecting as much relevant literature as possible; systematic reviews document the search strategy to verify its rigour and completeness; systematic reviews require explicit inclusion and exclusion criteria when assessing potential material; systematic reviews specify the information to be obtained from each primary study as well as quality criteria by which the material will be evaluated (Kitchenham, 2004, p. 3).

2.6.1 Process and Documentation for a Systematic Literature Review

Although quite similar, different authors have varied opinions about the key steps to follow when doing a systematic literature review. Hemingway and Brereton (2009, p. 1) classify the following steps: identifying the relevant evidence; selecting studies or reports for inclusion; assessing the quality of these reports or studies; synthesising the findings in an unbiased way; interpreting the findings, and presenting a balanced, impartial summary of the findings. Kitchenham (2004, p. 3) provides a more expanded version and identifies three main phases, each of which encompasses a number of stages. The phases are: planning, conducting and reporting the review. The planning phase includes the stages of identifying the need for a review and developing a review protocol. The phase of conducting the review includes the stages: identifying the research, selecting the primary studies, quality assessment of studies, the extraction and monitoring of data, and data synthesis. The final phase of reporting the review consists of a single stage (Kitchenham, 2004, p. 3). Briner and Denyer (2012, p. 3) identify the following five key steps: (i) planning the review, (ii) locating studies, (iii) appraising contributions, (iv) analysing and synthesising information, and (v) reporting evidence. Khan, Kunz, Kleijnen, and Antes (2003, p. 118) also identify five steps. These are (i) framing the question, (ii)
identifying relevant publications, (iii) assessing study quality, (iv) summarising the evidence, and (v) interpreting the findings.

For the purposes of this study, I have made use of the following steps to perform the systematic literature review:

i) Identify the need for a review (Kitchenham, 2004)
ii) Identify the relevant evidence (Hemingway & Brereton, 2009)
iii) Select studies and reports for inclusion (Briner & Denyer, 2012; Hemingway & Brereton, 2009; Khan et al., 2003)
v) Analyse and synthesise information (Briner & Denyer, 2012; Hemingway & Brereton, 2009)
vi) Interpret findings (Hemingway & Brereton, 2009; Khan et al., 2003)

2.6.2 Search Process Documentation

The systematic literature review was documented in detail (Briner & Denyer, 2012, p. 4; Kitchenham, 2004, p. 3). All searches were recorded in detail, including the date, keywords used, the database in which the search took place, and the number of hits. With reference to the inclusion and exclusion criteria (Kitchenham, 2004, p. 3), documents were identified. In total, thirteen searches were performed independently and in collaboration with expert librarians.

The systematic literature search was done using the following keywords: realistic* or RME, teach* or learn* or educat*, math*, tech* or ict or educat* tech*. Various combinations of these keywords were used to perform the searches. The databases that were used were: Scopus, EBSCOHost, Web of Science, Science Direct, MathSciNet, and Google Scholar.

The initial searches on the various databases were done using different combinations of the keywords. A record of this process was tabulated (Addendum 2.3). Thereafter, author maps for six authors who were dominant in the search results were drawn on each of the databases. An additional 36 searches were done. The six dominant authors were LM (Michiel) Doorman, Paul Drijvers, Koeno PE Gravemeijer, AJP (André) Heck, PBJ (Peter) Boon and Nicholas Zaranis. Table 2.3 summarises each of these authors’ field of expertise.

<table>
<thead>
<tr>
<th>The Dominant Authors</th>
<th>Field of Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof Dr Michiel Doorman</td>
<td>Interests are context-based Mathematics education; Modelling as a lever for learning Mathematics; Inquiry based learning and Coherency between</td>
</tr>
</tbody>
</table>

35
2.6.3 Selection Process Criteria Documentation

After the searches had been performed, documents were screened for their aptness for this study. In total 318 documents were perused and evaluated for their suitability. The process was recorded in detail in nine different Excel sheets (Addendum 2.4). The research revolved around four main concepts: i) Realistic Mathematics Education, ii) ICT, iii) Mathematics/teacher/education, and iv) Mathematics education, and documents were screened for content relating to these themes. Initially the title and abstract were perused for suitability. Thereafter the full text was read to determine its appropriateness for this study. Only documents that related to all four themes were selected. As discussed above, the author search was done and ten additional sources were included for analysis. Six articles were hand-picked and also included.

Once the coding and analysing of the documents took place, and I began to document the literature, I realized that the key authors in the field were regularly referred to by the identified sources. It was therefore necessary to include six core articles that relate specifically to the study. These sources are authored by the key role players of the RME movement in the Netherlands, namely Hans Freudenthal, Adrian Treffers and Martin Simon. Table 2.4 indicates each of these authors’ field of expertise.

<table>
<thead>
<tr>
<th>The Key Role players of the Realistic Mathematics Education Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Role players of RME movement</strong></td>
</tr>
<tr>
<td>Prof Dr Hans Freudenthal</td>
</tr>
<tr>
<td>Prof Dr Adrian Treffers</td>
</tr>
<tr>
<td>Prof Dr Martin Simon</td>
</tr>
</tbody>
</table>

The additional sources were coded and included in the systematic review for consideration.

2.6.4 Quality Assessment of Primary Documents

In order to select suitable documents for inclusion in the review, I studied all documents that were identified in the various searches and applied the quality assessment. The assessment of the
documents was done in collaboration with peers in the field of Mathematics education who acted as additional independent reviewers. The criteria for the selection of documents related to documents that:

- addressed at least four of the key concepts encompassed in this research
- related to qualitative, quantitative or mixed-method research
- published in books, accredited journals or conference proceedings
- were published between 2000 and 2015.

Figure 2.7 presents the process that was followed to assess and select the final documents for inclusion.

![Diagram of the process of primary document selection]

**Figure 2.7: The Process of Primary Document Selection**

### 2.6.5 Data Analysis for the Systematic Literature Review

When doing the systematic literature review, I used ATLAS.ti™ to code, sort and analyse the data. ATLAS.ti™ is part of the genre of Computer Assisted Qualitative Data Analysis Software (CAQDAS) (Friese, 2014b, p. 1). Software such as ATLAS.ti™ offers many advantages such as: it allows for easier systematic data analysis; large volumes of data and different media types can be structured and integrated quickly; it increases the validity of research results; codes and concepts can be modified as the analysis progresses (Friese, 2014b, p. 1). The three basic aspects of computer-assisted analysis are preparing data and creating a project file, coding the data, and using the software to sort and structure them with the aim of discovering patterns and relations (Friese, 2014b, p. 15). ATLAS.ti™ has very domain specific terminology that describes different aspects and processes of the software; this terminology is presented in Table 2.5.
Table 2.5  Domain Specific Terminology in ATLAS.ti™

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hermeneutic unit (HU)</td>
<td>A data file that stores everything that gets done to the data (Friese, 2014b, p. 37). The container that keeps track of all your data (Friese, 2015, p. 7). It helps to structure the data for each project (Friese, 2014a, p. 14).</td>
</tr>
<tr>
<td>Primary document</td>
<td>As documents are added to the project, ATLAS.ti™ creates a primary document (Friese, 2014b, p. 37). The primary document represents the data that you are analysing in your project (Friese, 2014a, p. 14).</td>
</tr>
<tr>
<td>Codes</td>
<td>Often a researcher-generated word or phrase that assigns a particular attribute to a portion of data (Saldaña, 2013, p. 262). A word or string of words used to name a category in data analysis (Boeije, 2010, p. 95). Keywords that are normally linked to quotations (Friese, 2014b, p. 36)</td>
</tr>
<tr>
<td>Categories</td>
<td>A group or cluster used to sort parts of the data during analysis (Boeije, 2010, p. 95). The aim of having a system to code data is to organise the data into categories and subcategories. Main category codes are developed by the process of conceptualisation, comparing and contrasting data segments (Friese, 2014b, p. 158).</td>
</tr>
<tr>
<td>Coding</td>
<td>Coding is the basic activity you engage in when working with ATLAS.ti™. It is the basis of everything else that you do further in ATLAS.ti™. It refers to the procedure of allocating categories, concepts or codes to sections of information that is of interest to your research goals (Friese, 2015, p. 7).</td>
</tr>
<tr>
<td>Quotation</td>
<td>Quotations are marked data segments that have a defined start and end point (Friese, 2014b, p. 38). A quotation refers to coded segments (Friese, 2015, p. 18).</td>
</tr>
<tr>
<td>Theme</td>
<td>That which the data are mainly concerned with (Boeije, 2010, p. 95).</td>
</tr>
<tr>
<td>Memos</td>
<td>Memos are places to write down all sorts of thoughts and ideas (Friese, 2014b, p. 37). Memos are independent objects that can stand alone or be connected to other objects (Friese, 2015, p. 36).</td>
</tr>
<tr>
<td>Code families</td>
<td>Code families are used to group codes together that belong together (Friese, 2014a, p. 234).</td>
</tr>
<tr>
<td>Network views</td>
<td>Network views allow one to visualise different aspects within the data. A few examples of what can be visualised are: your codings; relationships between codes; relationships between quotations; relationships between memos and quotes and many more (Friese, 2014b, p. 37).</td>
</tr>
</tbody>
</table>

There are a number of basic steps that need to be followed when working with ATLAS.ti™. As is illustrated in Figure 2.8, the process for this study began by creating a hermeneutic unit (HU), which contains the primary documents, quotes, code words, notes, memos, links, code families and network views (Friese, 2014b, p. 24).

![Figure 2.8 The ATLAS.ti™ Workflow Process adapted from Friese (2014a, p. 27)](image-url)
It is not important that all the steps follow sequentially, logic dictates which can be shifted out of order (Friese, 2014a, p. 27). I did not follow all these steps sequentially. The six additional documents that were not assigned to the project initially were added to the project at a later stage as the need arose. I created the HU with the title “Systematic literature review relating to the use of ICT to facilitate the principles of Realistic Mathematics Education to enhance teaching practice.” The 45 primary documents that were assigned to the HU included 29 journal articles, seven conference proceedings, six conference papers, one book section and two books. Relevant segments of the data were identified and coded. I did not use a pre-determined list of codes, and created codes as the different themes emerged in the data. I coded the data and created memos where necessary. Quotations, codes, categories and network views were created. I made use of inductive data analysis, since I did not have a pre-determined set of coding categories. This requires of the researcher to be immersed in the text until themes and concepts emerge from the data (Hesse-Biber & Leavy, 2006, p. 311).

As described in Table 2.5, a code is a word or phrase that assigns an attribute to a portion of data (Saldaña, 2009, p. 3). Codes are the building blocks for the construction of theory and models and form the basis of the analyst’s argument; they exemplify the assumptions on which the analysis is built (MacQueen, McLellan, Kay, & Milstein, 1998, p. 31). Codes can be developed from existing theory or concepts; from raw data and from a project’s research goals and questions (DeCuir-Gunby, Marshall, & McCulloch, 2011, p. 138). I created 58 codes in the process of analysing the documents.

A codebook is the compilation of the codes, the description of the content and a short data example for orientation (DeCuir-Gunby et al., 2011, p. 138; Saldaña, 2009, p. 21). Codebooks are especially critical when multiple team members work together on a project (Saldaña, 2009, p. 21). MacQueen et al. (1998, p. 32), who work with team-based qualitative analysis, describe the structure of the codebook as consisting of the following six components: “the code, a brief definition, a full definition, guidelines for when to use the code, guidelines for when not to use the code, and examples.” DeCuir-Gunby et al. (2011, p. 138) on the other hand use only three components, namely “code name/label, full definition (an extensive definition that collapses inclusion and exclusion criteria), and an example.”

Coding enables researchers to engage in reducing and simplifying the data and converting these into meaningful units. This allows researchers to make connections between ideas and concepts (DeCuir-Gunby et al., 2011, p. 138). DeCuir-Gunby et al. (2011, p. 141) describe the steps for developing theory-driven data as follows: generating the code; reviewing and revising the code and establishing the reliability of the code and coders. I followed this process when doing the systematic literature review. I generated codes (Table 2.6); reviewed and revised the codes within the context of the data; and established the reliability of the codes and coder by inviting a peer who is an expert in the field of Mathematics education and Systematic Literature Reviews to peer-code two articles of the systematic literature review. This will be discussed further on in this section.
Mathematization is the process of developing Mathematics concepts that originated in the real world (Cahyono, 2012, p. 72).

"It is based on the view of Freudenthal (1991) that mathematics is a human activity and that reality can be used as a source for mathematization." (Widjaja & Heck, 2003, p. 4).

"The development of an HLT and the design of instructional activities are closely related: the HLT guides the design of the instructional activities, but choices made in the design process may lead to reconsideration of the HLT" (Bakker, Doorman, & Drijvers, 2003).

"Task design is widely recognized as an important, but complex and subtle activity" (Drijvers, Boon, Doorman, Bokhove, & Tacoma, 2013, p. 1).

"According to the emergent modelling perspective, a model may play different roles during different phases of activity. Initially, a model is context-specific: it refers to a meaningful problem situation that is experientially real for the student, and is a model of that situation" (Drijvers et al., 2013, p. 1).

"The principle of guided reinvention seems to apply well to digital design. ICT offers opportunities for exploration and investigation, and in this way for reinvention" (Drijvers et al., 2013, p. 7).

"The teacher also mentioned the fact that in the school’s final assessment, the pupils involved in this research outscored those in the other class who he had taught the same topic in the traditional way and who he considered to be stronger in mathematics" (Widjaja & Heck, 2003, p. 20).

"The five characteristics of RME are: the use of contextual problems; the use of models; the use of pupils’ contributions; interactivity; and intertwining of learning strands" (Widjaja & Heck, 2003, pp. 4-5).

"Uhm, in Financial Mathematics as well. Through and through it every day life situation where you talk of borrowing, investments and other areas of activities" (P61:12).

"I think exponents is problematic and algebra, functions” (P59:60).

"It should be noted that starting with real situations and real data is not at all easy” (Widjaja & Heck, 2003, p. 22).

"According to Freudenthal (1991), mathematics as human activity and mathematics must be connected to reality. Therefore, students should be able to understand the concepts of mathematics and its application in the real world” (Cahyono, 2012, p. 71).

Table 2.6  Codebook Table

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLT</td>
<td>A hypothetical learning trajectory refers to what the teacher predicts about the path by which learning might progress(Simon, 1995, p. 135).</td>
<td>“The development of an HLT and the design of instructional activities are closely related: the HLT guides the design of the instructional activities, but choices made in the design process may lead to reconsideration of the HLT” (Bakker, Doorman, &amp; Drijvers, 2003).</td>
</tr>
<tr>
<td>Design of activities</td>
<td>Activities or tasks that are designed based on the principles and characteristics of RME.</td>
<td>“Task design is widely recognized as an important, but complex and subtle activity” (Drijvers, Boon, Doorman, Bokhove, &amp; Tacoma, 2013, p. 1).</td>
</tr>
<tr>
<td>Didactical phenomenology</td>
<td>One of the three key principles or heuristics of the design of teaching. It confronts students with phenomena that need to be organised by mathematical structures (Bakker et al., 2003, p. 5).</td>
<td>“Didactical phenomenology concerns the relation between the thought object–the ‘nooumenon’–and the phenomenon–the ‘phenomenon’–from the perspective of teaching and learning. In particular, it addresses the question how mathematical ‘thought objects’ can help in organizing and structuring phenomena in reality” (Drijvers et al., 2013, p. 1).</td>
</tr>
<tr>
<td>Emergent modelling</td>
<td>Problem situation are used that lead to models that initially represent the problem situation, but that have the potential to develop into general models (Bakker et al., 2003, p. 5).</td>
<td>“According to the emergent modelling perspective, a model may play different roles during different phases of activity. Initially, a model is context-specific: it refers to a meaningful problem situation that is experientially real for the student, and is a model of that situation” (Drijvers et al., 2013, p. 1).</td>
</tr>
<tr>
<td>Guided reinvention</td>
<td>A principle of RME where students are given the opportunity to experience a process similar to how a topic was invented (Drijvers et al., 2013, p. 1).</td>
<td>“The principle of guided reinvention seems to apply well to digital design. ICT offers opportunities for exploration and investigation, and in this way for reinvention” (Drijvers et al., 2013, p. 7).</td>
</tr>
<tr>
<td>Advantages of using RME</td>
<td>Any positive aspect related to the implementation or use of RME characteristics and principles.</td>
<td>“The teacher also mentioned the fact that in the school’s final assessment, the pupils involved in this research outscored those in the other class who he had taught the same topic in the traditional way and who he considered to be stronger in mathematics” (Widjaja &amp; Heck, 2003, p. 20).</td>
</tr>
<tr>
<td>Characteristics of RME</td>
<td>The attributes or tenets of RME.</td>
<td>“The five characteristics of RME are: the use of contextual problems; the use of models; the use of pupils’ contributions; interactivity; and intertwining of learning strands” (Widjaja &amp; Heck, 2003, pp. 4-5).</td>
</tr>
<tr>
<td>Content easy to relate to real life</td>
<td>Teacher-students expressed their views on which content in the curriculum is easiest to relate to real life situations.</td>
<td>“Uhm, in Financial Mathematics as well. Through and through it every day life situation where you talk of borrowing, investments and other areas of activities” (P61:12).</td>
</tr>
<tr>
<td>Content where need help to relate to real life</td>
<td>Teacher-students discussed which areas of the curriculum they felt they needed help in relating the content to real life situations.</td>
<td>“I think exponents is problematic and algebra, functions” (P59:60).</td>
</tr>
<tr>
<td>Disadvantages of using RME</td>
<td>Any negative aspect related to the implementation or use of RME characteristics and principles.</td>
<td>“It should be noted that starting with real situations and real data is not at all easy” (Widjaja &amp; Heck, 2003, p. 22).</td>
</tr>
<tr>
<td>Human activity</td>
<td>Freudenthal viewed Mathematics as a human activity, where reality is used as a foundation of mathematization.</td>
<td>“According to Freudenthal (1991), mathematics as human activity and mathematics must be connected to reality. Therefore, students should be able to understand the concepts of mathematics and its application in the real world” (Cahyono, 2012, p. 71).</td>
</tr>
<tr>
<td>Mathematization</td>
<td>Mathematization is the process of developing Mathematics concepts that originated in the real world (Cahyono, 2012, p. 72).</td>
<td>“It is based on the view of Freudenthal (1991) that mathematics is a human activity and that reality can be used as a source for mathematization.” (Widjaja &amp; Heck, 2003, p. 4).</td>
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<tr>
<td><strong>Principles of RME</strong></td>
<td>The theory of RME produced three principles according to which activities are designed, namely: guided reinvention, didactical phenomenology and emergent modelling. (Drijvers et al., 2013, p. 1).</td>
<td>“this brief exploration of the issue suggests that the three RME principles are valuable for digital design, even if some appropriation is needed compared to the design of paper-and-pencil tasks, such as taking into account the constraints of the digital tools and the fact that the technological environment forms an additional ‘world’ to the student” (Drijvers et al., 2013, p. 7).</td>
</tr>
<tr>
<td><strong>Real life</strong></td>
<td>Situations that are linked to reality; experientially real, everyday life phenomena.</td>
<td>“In RME pupils learn mathematics based on activities they experience in their daily life; pupils have a big opportunity to construct their knowledge by themselves, etc.” (Fauzan et al., 2013, p. 172).</td>
</tr>
<tr>
<td><strong>Recommendations for RME based lessons</strong></td>
<td>Any suggestions and recommendations presented in the literature for lessons based on the RME approach.</td>
<td>“The pupils could use the student book without any difficulties and they could learn the topic Area and Perimeter as intended according to the RME point of view. The teacher guide was useful for the teachers in implementing the RME-based geometry course” (Fauzan et al., 2013, p. 172).</td>
</tr>
<tr>
<td><strong>RME tasks</strong></td>
<td>Tasks and activities specifically designed using the principles and characteristics of RME.</td>
<td>“Gravemeijer and Doorman (1999) stressed that research on the design of Realistic Mathematics Education (RME) based activities has shown that the use of personalized contexts improved word problem solving by increasing the meaningfulness of contexts and enhancing student motivation” (Mousoulides, Sriraman, &amp; Christou, 2007, p. 29).</td>
</tr>
<tr>
<td><strong>Advantages, disadvantages and recommendations for RME</strong></td>
<td>Positive and negative critique about RME as well as suggestions and commendations regarding RME.</td>
<td>“RME is a guide for student learning that focuses on the development of abstract thinking” (Fitzallen &amp; Watson, 2014, p. 263).</td>
</tr>
<tr>
<td><strong>Aspects of RME</strong></td>
<td>These include features of RME other than the three principles or five characteristics, such as real life; human activity etc.</td>
<td>“According to Freudenthal (1983), mathematics is a human activity and therefore it must constitute a human value, must be close to reality of fact, be close to children and have a relationship with society” (Zaranis, Kalogiannakis, &amp; Papadakis, 2013, p. 5).</td>
</tr>
<tr>
<td><strong>RME</strong></td>
<td>RME is the acronym for Realistic Mathematics Education which is a “domain specific instruction theory for the teaching and learning of Mathematics” (Drijvers et al., 2013, p. 1)</td>
<td>“In the concept of RME, mathematics is a human activity connected with reality” (Widjaja &amp; Heck, 2003).</td>
</tr>
<tr>
<td><strong>RME theory</strong></td>
<td>The theoretical framework of Realistic Mathematics Education</td>
<td>“The Realistic Mathematics Education (RME) approach was the key theoretical framework for the design of the software and of the instructional material, and for the flanking educational research” (Heck, Boon, Bokhove, &amp; Koolstra, 2007, p. 2).</td>
</tr>
<tr>
<td><strong>Approaches to teaching Mathematics</strong></td>
<td>Various teaching approaches such as the traditional approach, constructivism, problem-solving approach and RME.</td>
<td>“The traditional way of teaching had a negative influence on the pupils’ attitudes towards mathematics which means that most pupils did not like to learn mathematics, and that some of them were even afraid of mathematics” (Fauzan et al., 2013, p. 161).</td>
</tr>
<tr>
<td><strong>Modelling</strong></td>
<td>This refers to mathematical modelling which can take on various forms such as physical models, equations, dynamic systems etc.</td>
<td>“The idea is to look for models that can be generalized and formalized to develop into entities of their own, which then can become models for mathematical reasoning” (Doorman et al., 2008, p. 2).</td>
</tr>
<tr>
<td><strong>Learner reasoning</strong></td>
<td>The process that learners go through where they ponder on and evaluate ideas.</td>
<td>“The RME philosophy also suggests instruction should build students’ reasoning gradually from the concrete to the abstract, through the use of manipulatives, diagrams, and other imagery to reinforce students’ reasoning” (Fitzallen &amp; Watson, 2014, p. 264).</td>
</tr>
<tr>
<td><strong>Learner understanding</strong></td>
<td>When learners are given the opportunity to learn with deep</td>
<td>“The results of research in the Netherlands showed that the RME has shown satisfactory results. RME</td>
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<tr>
<td></td>
<td>understanding.</td>
<td>has the potential to improve students' understanding of mathematics (Streefland, 1991)&quot; (Cahyono, 2012, p. 72).</td>
</tr>
<tr>
<td>Mathematics education</td>
<td>All aspects that relate to the teaching and learning of Mathematics.</td>
<td>&quot;For over two decades, many stakeholders have highlighted the potential of digital technologies for mathematics education&quot; (Driviers, 2013, p. 1).</td>
</tr>
<tr>
<td>Maths strategies</td>
<td>Learning and teaching strategies used in Mathematics education.</td>
<td>&quot;Context problems are selected, offering the students the opportunity to develop situation-specific representations and strategies&quot; (Doorman et al., 2008, p. 2).</td>
</tr>
<tr>
<td>Meaningful learning of Maths</td>
<td>When that which is learned is fully understood in whole and related parts.</td>
<td>&quot;active participation is promoted when students make artefacts that are meaningful and useful to them&quot; (Fitzallen &amp; Watson, 2014, p. 264).</td>
</tr>
<tr>
<td>Problem areas to teach/learn</td>
<td>Teacher-students discussed the areas of the content that they found problematic to teach and the areas that their learners found difficult to learn.</td>
<td>&quot;Learners do have a problem with algebra and integers in fact. If they do have a problem with integers, it is going to give them a problem when dealing with algebra&quot; (P59:12).</td>
</tr>
<tr>
<td>Teaching methods and strategies</td>
<td>General teaching methods and strategies</td>
<td>&quot;This nation-wide reform now has an established record (Vos, 2010) that speaks directly to the building of mathematics competence, but also addresses issues of ways of working, cooperation, problem solving and metacognition&quot;(Gordon, Rey, Siewiorek, Vivitsou, &amp; von Reis Saari, 2012, p. 21).</td>
</tr>
<tr>
<td>Factors that influence teaching and learning</td>
<td>Any factor or aspect that plays a role in teaching and learning</td>
<td>&quot;Another factor that is not so much elaborated in the case descriptions but is important to mention here, is assessment, which should be in line with the students’ activities with technology; not doing so would suggest that in the end the use of digital technology is not important&quot; (Driviers, 2013, p. 15).</td>
</tr>
<tr>
<td>Learner aspects</td>
<td>Any aspect that influences the learner specifically in relation to the learning of Mathematics, with particular attention to learner understanding and learner reasoning</td>
<td>&quot;The effectiveness of the RME-based geometry course had also to be investigated in order to show its effect on the pupils' learning&quot; (Fauzan et al., 2013, p. 171).</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Freudenthal (1968, p. 4)argues that Mathematics has proved indispensable for the understanding and the technological control of both the physical world and the social structure. Mathematics has been described by some as a static discipline developed abstractly, while others see it as a dynamic discipline constantly changing due to new discoveries (Dossey, 1992, p. 39). Other authors describe Mathematics as the science of pattern and order, which challenges the view that Mathematics is merely a discipline dominated by computation (Van de Walle et al., 2013, p. 13). Mathematics is also described as a human endeavour in which ordinary people construct concepts, discover relationships, invent methods, execute algorithms, communicate and solve problems posed by the real world (Cangelosi, 2003, p. 7).</td>
<td>&quot;This is also in line with the objective of realistic mathematics education (RME), where instructional design is aimed at creating optimal opportunities for the emergence of formal mathematical knowledge from situation specific reasoning&quot; (Doorman et al., 2008, p. 1).</td>
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<tr>
<td>Mathematics content</td>
<td>Content areas at any level of the Mathematics school curriculum. Both formal and informal Mathematics is included in this category.</td>
<td>&quot;Within this perspective, we can distinguish between formal and informal by denoting formal mathematical reasoning as a form of reasoning that builds on arguments that are located in the newly formed mathematical reality. Seen this way, the distinction between informal and formal is a relative distinction—a distinction that is relative to a certain topic and that can be made especially from an observer perspective&quot; (Gravemeijer, 1999, p. 160).</td>
</tr>
<tr>
<td>Community</td>
<td>One of the role players that can influence the teaching and learning of Mathematics as expressed by the teacher-students.</td>
<td>&quot;But, maybe only, let me say ten percent of our children have got a good background, they have got a satellite dish. So mostly they are from shacks, where they do not have electricity, you know...&quot; (P60:211).</td>
</tr>
<tr>
<td>Context</td>
<td>Another factor that the teacher-students identified that serves as a role player in the teaching and learning of Mathematics.</td>
<td>&quot;Ja, last time when we were using the overhead projectors, but now the state of our school we cannot, we have so many projectors here, but they are not functioning&quot; (P49:76).</td>
</tr>
<tr>
<td>Learner</td>
<td>Learners also are role players in the teaching and learning of Mathematics. Teacher-students voiced their opinions about the role that learners play.</td>
<td>&quot;You see, most of our learners they are not, how can I say it, they are not familiar with the situations&quot; (P49:38).</td>
</tr>
<tr>
<td>Role players</td>
<td>Any person or aspect that plays a role in the teaching and learning of Mathematics.</td>
<td>&quot;Involving different stakeholders and especially teachers in the design process is a key factor for an innovative learning activity to find its way to teachers’ everyday practice&quot; (Perez, 2012, p. 21).</td>
</tr>
<tr>
<td>Teacher</td>
<td>Teacher-students expressed their views about teachers as role players in the teaching and learning of Mathematics.</td>
<td>&quot;Then, recently we have Euclidean geometry which has been introduced. Uhm, it’s also a major problem, but I think the problem is not the learners but maybe the majority of teachers who are teaching that, they did not even do it during their times at school. It’s something that was brought in as a crash programme for teachers to be taught as well. So, those are the main three areas: Euclidean geometry, trigonometry and functions&quot; (P61:6).</td>
</tr>
<tr>
<td>Integration across strands</td>
<td>One of the characteristics of RME. This deals with the integration of content across the curriculum.</td>
<td>&quot;So this is how now I’m learning, right from grade twelve. Because if you’re teaching it at grade twelve, there are some of the concepts that you don’t know at the grade eleven and grade ten level&quot; (P49:18).</td>
</tr>
<tr>
<td>Learning environment</td>
<td>The atmosphere and space that is created in which learning can take place.</td>
<td>&quot;Yes, the learners present and they present it so well, they present it so well. In the meantime they are also learning, you understand? They are also learning. So, I also tell some other learners they must also do it, because you gain more knowledge by just standing there and going home to prepare the topic to do it. They come prepared and then they do it so nicely&quot; (P60:235).</td>
</tr>
<tr>
<td>Student support</td>
<td>Support that is rendered to the students in terms of their learning.</td>
<td>&quot;While pre-enrolment testing establishes learner readiness for participating in a course, the pre-course diagnostic testing is conducted to determine the amount and level of support a learner will require to advance successfully within the course&quot; (Kizito, 2012a, p. 39).</td>
</tr>
<tr>
<td>Distance education</td>
<td>Distance learning that offers students flexible learning opportunities at their convenience.</td>
<td>&quot;In the South African distance education environment, where the majority of students simply cannot afford access to web-based learning, the use of a mLearning strategy seems to be a viable and rational alternative for providing instructional support&quot; (Kizito, 2012a, p. 39).</td>
</tr>
<tr>
<td>Motivation</td>
<td>Factors that encourage and inspire teachers or learners in the process of teaching and learning.</td>
<td>&quot;In our opinion, digital assignments and diagnostic testing add to the motivation and performance of students in mathematics education&quot; (Heck et al., 2007, p. 18).</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
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<tr>
<td>Pedagogy</td>
<td>An aspect that has to do with the theory and practice of education.</td>
<td>“even if the digital technology’s affordances and constraints are important design factors, the main guidelines and design heuristics should come from pedagogical and didactical considerations rather than being guided by the technology’s limitations or properties” (Drijvers, 2013, p. 15).</td>
</tr>
<tr>
<td>Social aspects</td>
<td>Any social aspect in the teaching and learning of Mathematics. This can include social norms and social interaction.</td>
<td>“The third level of the teaching procedure included activities using appropriate social interaction to refine the models of the problem” (Zaranis, 2014a, p. 62).</td>
</tr>
<tr>
<td>TPACK</td>
<td>The three main components of teachers’ knowledge: content, pedagogy and technology. These aspects, as well as the interaction between them are important.</td>
<td>“To be able to do so, a process of professional development is required, which includes the teacher’s own instrumental genesis, or, in terms of the TPACK model, the development of his technological and pedagogical content knowledge” (Drijvers, 2013, p. 15).</td>
</tr>
<tr>
<td>Challenges when working with ICT</td>
<td>Any aspect relating to ICT that is problematic.</td>
<td>“There are some disadvantages, too. When a school already uses a VLE, with all kinds of communication facilities such as email and bulletin board available, it could be considered cumbersome that yet another environment is added to the already long list” (Heck et al., 2007, p. 8).</td>
</tr>
<tr>
<td>ICT systems: virtual learning environment (VLE)</td>
<td>Various ICT systems and virtual learning environments are represented here.</td>
<td>“As technology for teaching mathematics the Freudenthal Institute’s Digital Mathematics Environment (DME) is used. The DME integrates a content management system, a learning management system and an authoring environment. The content consists of online modules in the form of Java applets. The learning management system offers means to distribute content among students and to monitor student progress” (Drijvers et al., 2013, p. 2).</td>
</tr>
<tr>
<td>Teacher-student ICT factors</td>
<td>Factors relating to ICT that play a role in the teacher-students’ teaching environment.</td>
<td>“Ja, we could prepare in advance. And then presently we’ve got only one projector in the school, so it is difficult to use the laptop when teaching. And some of the classes do not have electricity. That’s another problem” (P49:80).</td>
</tr>
<tr>
<td>Technology as educational tool</td>
<td>An aspect where technology is used as an educational tool or has potential to be used as an educational tool.</td>
<td>“Yes, they have the tablet. We have the interactive whiteboard, but we the teachers are still struggling to use the interactive whiteboard. Most especially for Maths” (P60:22).</td>
</tr>
<tr>
<td>Value of using ICT</td>
<td>The advantages or benefits of using ICT in the educational arena.</td>
<td>“In our opinion, digital assignments and diagnostic testing add to the motivation and performance of students in mathematics education” (Heck et al., 2007, p. 18).</td>
</tr>
<tr>
<td>Devices</td>
<td>Any technological device that can be used in educational practice, e.g. mobile phone, laptop, tablet.</td>
<td>“Observation of the students’ behavior during the experimental lessons supports the premise that the graphics calculator can stimulate the use of realistic contexts, the exploratory and dynamic approach to mathematics, a more integrated view of mathematics, and a more flexible behavior in problem solving” (Drijvers &amp; Doorman, 1996, p. 425).</td>
</tr>
<tr>
<td>ICT</td>
<td>This refers to the broad, encompassing term that includes all information and communication technology.</td>
<td>“In order to help teachers to benefit from technology in everyday mathematics teaching, therefore, it is important to have more knowledge about the new teaching techniques that emerge in the technology-rich classroom and how these relate to teachers’ views on mathematics education and the role of technology therein” (Drijvers et al., 2010a, p. 214).</td>
</tr>
<tr>
<td>Tools</td>
<td>Technology tools that aim to help teachers teach learners more effectively, such as software programmes,</td>
<td>“Two kinds of applets can be distinguished: model applets, which help to develop mathematical understanding (concepts), and exercise applets, which support the development of mathematical...”</td>
</tr>
</tbody>
</table>
Interrater reliability was calculated using Cohen’s kappa. This is an index of interrater reliability which is used to measure the level of agreement between two sets of ratings (Cohen, 1960, p. 37). Kappa is the portion of agreement between raters (Fleiss & Cohen, 1973, p. 613). Kappa ranges between -1.00 and +1.00, where a negative value indicates poor agreement, and a positive value indicates better than chance agreement (Fleiss & Cohen, 1973, p. 613). A kappa of zero indicates a random level of agreement or disagreement (Wood, 2007, p. 7). Wood (2007, p. 6) states that for research purposes, the kappa should be at least 0.60 or 0.70. For making applied decisions about a particular individual like doing intelligence tests, the kappa should be at least 0.80 or 0.90. The Cohen’s Kappa for the systematic literature review was calculated to be 0.98 (Addendum 2.5).

### 2.6.6 Validity and Reliability in the Systematic Literature Review

The validity and reliability of a study to a large degree depend on the ethics of the researcher (Merriam, 2009, p. 228). If the ethical standards of the researcher are not acceptable, it will negate the reliability and validity of the study. I have at all stages of the research adhered to the strict ethical standards of the NWU (§ 2.5), as well as conducted all aspects of the research in an ethical manner.

The importance of producing valid and reliable results and knowledge in research is invaluable (Merriam, 2009, p. 210). Validity is an important key to effective research (Cohen et al., 2011, p. 133). The following terms are extensively embraced in qualitative research: credibility, transferability, dependability, conformability (Merriam, 2009, p. 211), trustworthiness, authenticity and plausibility (Given, 2008, p. 909). Reliability refers to the replicability of research findings which in essence in social sciences is problematic, since human behaviour constantly varies (Merriam, 2009, p. 220).

Reliability is often referred to as the “dependability, consistency and/or repeatability of a project’s data collection, interpretation, and/or analysis” (Given, 2008, p. 753). To put these into practice, authors propose techniques such as spending extensive time in the field, triangulation and the use of thick description (Creswell, 2013, pp. 203-204).

Given (2008, p. 753) lists three of the commonly cited indicators of credibility and dependability that qualitative researchers use to demonstrate systematic attention to reliability issues as: i) methodological coherence, which refers to the appropriate and thorough collection, analysis and interpretation of data; ii) researcher responsiveness, which refers to the early and on-going verification of findings and analyses with participants; and iii) audit trails, which refer to the transparent

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<th>Code</th>
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<tr>
<td>Methodology</td>
<td>Different methodological approaches used in the literature, e.g. design-based research; action research.</td>
<td>“The three studies that are discussed in this paper combine the methodology of design research with a prominent role for the Hypothetical Learning Trajectory as a research instrument in all phases of design research (design, teaching experiment, retrospective analysis)” (Bakker et al., 2003, p. 1).</td>
</tr>
</tbody>
</table>
description of all procedures and issues relating to the research project. Creswell (2007, p. 206) suggests, amongst others, the following strategies to ensure validation in qualitative research: Prolonged engagement and persistent observation in the field; and rich, thick description, which helps readers make decisions about transferability. The manner in which I have complied with the indicators as suggested by Given (2008, p. 753) and Creswell (2007, p. 206) is illustrated in Table 2.7.

Table 2.7 Indicators of Credibility and Dependability in the Systematic Literature Review

<table>
<thead>
<tr>
<th>Indicator</th>
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<tbody>
<tr>
<td>Methodological coherence</td>
<td>I followed a scientific procedure to select relevant documents. The selection process was discussed in detail in § 2.6.1 – 2.6.3. Data analysis was systematically done with the aid of ATLAS.ti™.</td>
</tr>
<tr>
<td>Researcher responsiveness</td>
<td>The interpretation of the data was verified by a peer in the field of Mathematics education, who is also an expert in performing systematic literature reviews. Cohen's Kappa was calculated to verify the interrater reliability (§ 2.6.5)</td>
</tr>
<tr>
<td>Audit trails</td>
<td>All procedures that were followed in the selection, analysis and interpretation of the documents were described in detail in § 2.6.1.</td>
</tr>
<tr>
<td>Prolonged engagement</td>
<td>Over a period of a year, I selected, coded, analysed and documented the systematic literature review.</td>
</tr>
<tr>
<td>Rich, thick descriptions</td>
<td>I made use of an extensive scientific process that was documented and described in detail as to how documents were selected, coded and analysed. A detailed analysis of the literature follows in Chapter Three.</td>
</tr>
</tbody>
</table>

2.6.7 Limitations of the Systematic Literature Review

Although the systematic literature review has many benefits (§ 2.6), there are limitations involved in its use as well. Most importantly, systematic literature reviews can be performed badly (Hemingway & Brereton, 2009, p. 6). To overcome this problem, researchers should rigorously follow the steps documented for successful systematic literature reviews by various authors (§ 2.6.1). The most obvious limitation of a systematic literature review is the limited key words used in the search, the limited data-bases that were selected, as well as the limited time period of publication. The systematic literature review is a complex, intensive, rigorous and time-consuming method of doing a literature review. Despite these aspects, it still proved to be a suitable method for deriving a theoretical framework for the study.

2.7 Aspects for Intervention

The research questions and the exposition of the systematic literature review provided guidance and insight with regard to various aspects that required intervention. This overview was an ideal starting point which offered valuable insight into strategies that could be used to intervene. From this point the qualitative strategy, which took the form of a needs analysis, could be further used to refine the intervention process and assist the teacher-students in addressing their specific needs.
2.8 Qualitative strategy: Needs Analysis

One of the sub-questions posed to gain insight on the main research question for this study was: *What support needs do teachers have in order to successfully implement the RME approach in their teaching practice?* To answer this question, it was necessary to schedule a meeting with the teacher-students to establish what needs they had in terms of making the Mathematics content more realistic for their learners. I also used this opportunity to determine their views on what type of technology would be most suitable to address these needs.

2.8.1 Participant Selection

Two basic types of sampling can be used, namely probability sampling and nonprobability sampling. Nonprobability sampling is the most suitable choice for qualitative research, and the most common form of nonprobability sampling is purposive or purposeful sampling (Merriam & Tisdell, 2016, p. 96). Nonprobability sampling implies that the researcher targets a particular group knowing full well that it does not represent the wider population, it merely represents itself (Cohen et al., 2011, p. 155). Small-scale research often makes use of nonprobability sampling because the samples are less complicated to achieve, are considerable less costly and can prove perfectly adequate when researchers do not intend to generalise their findings, despite the disadvantages that can arise from the non-representativeness (Cohen et al., 2011, p. 155). Purposive sampling (participant selection) allows the researcher to select individuals and sites because they can provide an understanding of the research problem and principal phenomenon in the study (Creswell, 2013, p. 156). The number of participants in the sample varies, depending on the research. In phenomenology, the range of the number of participants can be from one to hundreds (Creswell, 2013, p. 157).

As mentioned in Chapter One, in this study, participants were selected from a group of in-service teachers enrolled for the BEd Honours post-graduate degree in Mathematics education at the NWU, which is delivered by means of both the face to face and ODL modes. The criteria for selection were:

(i) teacher-students enrolled at the NWU for the BEd Honours degree by means of either face to face or ODL mode,
(ii) teacher-students who attend contact classes for the degree in question,
(iii) teacher-students who are currently teaching Mathematics in any phase and
(iv) male and female teachers at various schools.

At the contact sessions in Potchefstroom, I made contact with the students who attended the presentations for the Mathematics modules in the course. I enquired of these students who would be willing to take part in this research, and collected their contact information. I approached these students for the initial interviews.
2.8.2 Site Selection

The selected site for this research was the Potchefstroom Campus of the North-West University. Part-time students enrolled at the Faculty of Education Sciences at the above-mentioned campus, for the BEd Honours post-graduate degree, specialising in Mathematics education, were invited to participate in the research.

There are a number of types of purposive sampling; the most appropriate for this study was convenience sampling. In convenience sampling, otherwise known as accidental or opportunity sampling (Cohen et al., 2011, p. 155), a sample is selected based on time, money, location and availability of sites or respondents (Merriam & Tisdell, 2016, p. 98). This sampling involves choosing the nearest individuals to serve as respondents until the sample size has been obtained (Cohen et al., 2011, p. 155). The advantage of using convenience sampling is that it saves time, money and effort, but this can impact on the information received and the credibility (Creswell, 2013, p. 158). Captive audiences like students or student teachers often serve as participants in convenience sampling (Cohen et al., 2011, p. 156). The researcher in this type of sampling needs to be particular about reporting that the parameters of being able to generalise are negligible (Cohen et al., 2011, p. 156). I made use of purposive sampling to select the site. Two of the interviews took place at the Potchefstroom Campus of the North-West University, which is a familiar terrain for the student-teachers as they regularly attend contact classes at this site. The third interview took place in the HOD’s office at one of the participant’s school in Potchefstroom. The fourth meeting took place at a coffee shop in Ventersdorp.

2.8.3 Methods of Data Generation or Collection

Interviews allow participants to discuss their interpretation of the world in which they live and to express their opinions on situations from their perspective (Cohen et al., 2011, p. 349). As Cohen et al. (2011, p. 349) describe it, the interview is “not simply concerned with collecting data about life: it is part of life itself, its human embeddedness is inescapable.” I made use of semi-structured individual interviews with the teacher-students to establish their needs in terms of making Mathematics more realistic for their learners. The RME approach has proved to enhance and improve learners’ understanding in Mathematics (Fauzan et al., 2013, p. 174). I also made use of observations of the participants’ classroom practice to establish the teacher-students’ needs with regard to making the curriculum content relevant for their learners. Individual as well as focus group interviews were used to further generate data. Focus group interviews should be used when interviewees are similar and the interaction between the interviewees will yield the best information (Creswell, 2007, p. 133). The interviews allowed me to gain in-depth knowledge of how teacher-students experience the intervention that is presented to them by means of different technologies, based on the RME approach. In order to ensure validity and reliability, the following measures were used: prolonged engagement and
persistent observation in the field, the use of thick, rich description and feedback from others (Creswell, 2007, p. 207).

2.8.3.1 Initial Testing of the Informal Discussion and Needs Analysis

An initial informal discussion was scheduled with a teacher with whom the researcher is familiar, to test the effectiveness and accuracy of the questions in the informal discussion. The teacher is currently teaching Mathematics at a rural secondary school in the Potchefstroom area. Some of the lecturers who are involved with distance education at the Faculty of Education Sciences at the NWU have since 2011 been involved in a school support programme with a particular school in the area. The support involves assisting grade 11 and 12 teachers and learners with Mathematics, via an Interactive White Board (IWB). The researcher is familiar with this teacher because of this support programme, since he is one of the Mathematics teachers at the school, and she is one of the lecturers involved in the support programme.

The initial informal discussion was recorded and transcribed. I together with my promoter coded the informal discussion with the aid of ATLAS.ti™. The existing codes that were created in the systematic literature review were used as well as a few additional codes that were necessary to create in the coding process. To ensure that the coding was done in sufficient detail, and to determine whether the questions were unambiguous and clear, the researcher and two peers perused the transcription again, and added additional codes where necessary. The two peers that assisted with this further coding are full-time Mathematics lecturers at the Faculty of Education Sciences at the NWU.

2.8.3.2 Individual Semi-structured Interviews

One of the most common ways of collecting qualitative data is the interview, which is used by researchers when they “cannot observe behaviour, feelings or how people interpret the world around them” (Merriam & Tisdell, 2016, p. 108). In the SAGE Encyclopaedia of Qualitative Research Methods, Given (2008, p. 422) distinguishes between different types of interviews. Merriam and Tisdell (2016, p. 109) use the same classification, namely structured, semi-structured and unstructured interviews. In-depth or semi-structured interviews are interviews in which participants are encouraged to talk in depth about a topic. The interview can be considered to be semi-structured, since the researcher maintains some control over the content and direction of the discussion, however participants are free to expand on their ideas and move the discussion into new but related directions (Given, 2008, p. 422). The conversation fluctuates between the researcher’s introduction of the topic, the participant’s description of his or her experiences and the researcher’s examining of these experiences for additional information (Given, 2008, p. 422). In a structured interview, the participant responds to a list of pre-determined topics or questions, and in an unstructured interview there are no preconceived topics or questions (Given, 2008, p. 422).
Four participants were approached to take part in the study. Individual semi-structured interviews were scheduled with each participant and an appropriate location was decided upon to do the interview. An interview schedule was loosely followed (Addendum 2.6). The questions in semi-structured interviews are flexibly worded and the interview is a mix of more or less structured questions (Merriam, 2009, p. 90). The main part of the interview is guided by a list of questions or issues that need to be explored. This allows the researcher to react to the situation as it arises (Merriam, 2009, p. 90). The first interview took place at the North-West University (NWU) Potchefstroom Campus.

The interviews were coded using ATLAS.ti™. Open-coding was used to code the interviews as this allowed me to explore ideas and meaning that were contained in the raw data (DeCuir-Gunby et al., 2011, p. 139). Codes that are driven by data involve five steps in order to create the codebook, namely: raw data are reduced; subsample themes are identified; themes are compared across subsamples; codes are created; and the reliability of codes is determined (DeCuir-Gunby et al., 2011, p. 141). These five steps were used in the study; firstly I perused paragraphs of the data to identify appropriate codes. The existing codes which were created in the systematic literature review were used, and where necessary, additional codes were created which were suited to the context and content of the data. This constituted step two, three and four. The final step to establish reliability was done by inviting two peers who are experts in the field of Mathematics education to peer code an interview. The Cohen’s Kappa for the individual interview was calculated to be 0.99 (Addendum 2.7).

Data saturation occurs when “continued data collection produces no new information or insights into the phenomenon you are studying” (Merriam & Tisdell, 2016, p. 199). By the third and fourth interview, no new information emerged in this study. Another indication of data saturation is concerned with the analysis of the data—if the categories, themes or findings are robust enough to cover what emerges in later data, then saturation occurs (Merriam & Tisdell, 2016, p. 199). When coding in ATLAS.ti™, no new codes or themes were added in the third or fourth interview, so I deemed four a sufficient number of participants for the study.

2.8.3.3 Data Analysis

Data were coded, sorted and summarised into themes or patterns which would aid the understanding and interpretation of what is emerging (Nieuwenhuis, 2010a, p. 99). This analysis was done with a Computer Assisted Qualitative Data Analysis Software (CAQDAS), ATLAS.ti™. Based on these findings, I could establish what sections of the curriculum the teachers and learners found most problematic, and also with which sections they needed help to relate the content to real life situations. As a result of what was revealed in the interviews, I could also decide on the appropriate use of technology to present the intervention, which was based on the principles and characteristics of RME.
2.9 Intervention Strategy: Design of the App

The needs analysis revealed two important aspects that directed the rest of the study (a detailed discussion is presented in Chapter Four). Firstly, participants needed assistance with ideas on how to make the Mathematics more realistic for their learners; and secondly, they were keen to use technology, specifically mobile technology, as a tool to learn how to apply the principles of RME in their teaching practice. It was therefore necessary to devise a strategy to intervene, that could address the issues raised. This intervention strategy took the form of an app that was designed for Android. With the help of a programmer and specialist in the design of applications, we designed an app for the teacher-students that could help them to make the content more realistic for their learners. The design process is documented in detail in Chapter Five.

2.10 Qualitative strategy: Participants’ Perceptions about the App

When the intervention tool, the Financial Mathematics app, had undergone various stages of refinement in the form of improved prototypes and it was completed, the programmer made it available on Google Play Store as a free app. It was necessary to make this app available to the teacher-students so as to establish their perceptions and opinions about the app.

2.10.1 Participant Selection

The same students that were selected for the initial interviews were approached for the follow-up focus group interview. One of the students that took part in the initial interview was not able to attend the focus group interview and an additional student who complied with the criteria in § 2.8.1 was approached to attend the focus group interview. This student was informed of the research process up to that point and agreed to take part in the focus group interview.

2.10.2 Site Selection

The same site was used as discussed in § 2.8.2. I met with teacher-students at an appropriate venue at the North-West University Potchefstroom Campus and made sure that all participants were comfortable.

2.10.3 Methods of Data Generation or Collection

A focus group interview was selected as the method of data generation. A focus group interview is an interview with a group of people who have a common interest or knowledge in a topic (Merriam, 2009, p. 93). It is beneficial when the interaction between the interviewees will produce the best information,
when the participants are similar and when they are willing to cooperate with each other (Creswell, 2007, p. 133). I decided to make use of the focus group interview for two reasons. Firstly, because I hoped that the interaction between participants would yield the most fruitful information. Secondly, I was also aware that the teacher-students were familiar with one another because they were studying the same course and attended contact classes together, so I hoped that that fact would encourage active cooperation between them. I designed an interview protocol (Creswell, 2007, p. 133) with ten questions. These questions were based on the literature review. The systematic literature review produced five main themes (Chapter Three), namely Mathematics, RME, ICT, role players and methodology. I designed questions which incorporated these themes in the process of evaluating and commenting on the app (Addendum 2.8).

2.10.3.1 Focus Group Interviews

Initially I planned to do one focus group interview with the four selected teacher-students. When contacting the students for a viable date and time to meet, I noted that one of the teacher-students was not able to attend the focus group interview at the same time as the others for logistical reasons. I decided to divide the group in two and proceeded with two focus group interviews, each attended by two students.

The purpose of the focus group interview was to introduce the teacher-students to the app on Financial Mathematics and to determine their views and opinions about it. The app was available for teacher-students to download free of charge on Google Play Store. I allocated time for them to familiarise themselves with the app before the scheduled questions (Addendum 2.8) were discussed. In this time, I was available to assist in any way they needed assistance. We then progressed to a discussion about the app and addressed the scheduled questions in the discussion. A detailed analysis of this discussion was presented in Chapter Six.

2.10.3.2 Data Analysis

I transcribed the two focus group interviews and analysed the data with the aid of ATLAS.ti™. The data analysis and interpretation were integrated with the literature review to answer the research questions. Based on these findings, guidelines for the effective use of technology in implementing the RME approach in teaching practice were designed. The detailed guidelines were presented in Chapter Seven.

All the data in the study were analysed in the same Hermeneutic Unit (HU) in ATLAS.ti™. The final list of codes as well as the code density, or the number of times each code was noted, is indicated in Table 2.8.
<table>
<thead>
<tr>
<th>Code</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLT</td>
<td>62</td>
</tr>
<tr>
<td>Design of activities</td>
<td>45</td>
</tr>
<tr>
<td>Didactical phenomenology</td>
<td>14</td>
</tr>
<tr>
<td>Emergent modelling</td>
<td>42</td>
</tr>
<tr>
<td>Guided reinvention</td>
<td>93</td>
</tr>
<tr>
<td>Advantages of using RME</td>
<td>26</td>
</tr>
<tr>
<td>Characteristics of RME</td>
<td>53</td>
</tr>
<tr>
<td>Content where need help to relate to real life</td>
<td>11</td>
</tr>
<tr>
<td>Disadvantages of using RME</td>
<td>6</td>
</tr>
<tr>
<td>Human activity</td>
<td>29</td>
</tr>
<tr>
<td>Mathematization</td>
<td>49</td>
</tr>
<tr>
<td>Principles of RME</td>
<td>1</td>
</tr>
<tr>
<td>Real life</td>
<td>22</td>
</tr>
<tr>
<td>Recommendations for RME based lessons</td>
<td>42</td>
</tr>
<tr>
<td>RME tasks</td>
<td>32</td>
</tr>
<tr>
<td>Aspects of RME</td>
<td>362</td>
</tr>
<tr>
<td>RME</td>
<td>16</td>
</tr>
<tr>
<td>Approaches to teaching Mathematics</td>
<td>118</td>
</tr>
<tr>
<td>Modelling</td>
<td>72</td>
</tr>
<tr>
<td>Content related to real life</td>
<td>27</td>
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<td>Learner reasoning</td>
<td>4</td>
</tr>
<tr>
<td>Learner understanding</td>
<td>8</td>
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<tr>
<td>Mathematics education</td>
<td>44</td>
</tr>
<tr>
<td>Maths strategies</td>
<td>4</td>
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<tr>
<td>Meaningful learning of Maths</td>
<td>66</td>
</tr>
<tr>
<td>Problem areas to teach/learn</td>
<td>17</td>
</tr>
<tr>
<td>Teaching methods and strategies</td>
<td>105</td>
</tr>
<tr>
<td>Factors that influence teaching and learning</td>
<td>249</td>
</tr>
<tr>
<td>Learner aspects</td>
<td>36</td>
</tr>
<tr>
<td>Mathematics</td>
<td>130</td>
</tr>
<tr>
<td>Mathematics content</td>
<td>125</td>
</tr>
<tr>
<td>Community</td>
<td>11</td>
</tr>
<tr>
<td>Context</td>
<td>35</td>
</tr>
<tr>
<td>Learner</td>
<td>19</td>
</tr>
<tr>
<td>Role players</td>
<td>205</td>
</tr>
<tr>
<td>Teacher</td>
<td>99</td>
</tr>
<tr>
<td>Integration across strands</td>
<td>6</td>
</tr>
<tr>
<td>Learning environment</td>
<td>7</td>
</tr>
<tr>
<td>Student support</td>
<td>5</td>
</tr>
<tr>
<td>Distance education</td>
<td>13</td>
</tr>
<tr>
<td>Motivation</td>
<td>14</td>
</tr>
<tr>
<td>Pedagogy</td>
<td>71</td>
</tr>
<tr>
<td>Social aspects</td>
<td>13</td>
</tr>
<tr>
<td>TPCK</td>
<td>6</td>
</tr>
<tr>
<td>Challenges when working with ICT</td>
<td>56</td>
</tr>
<tr>
<td>ICT systems: virtual learning environment (VLE)</td>
<td>85</td>
</tr>
<tr>
<td>Teacher-student ICT factors</td>
<td>79</td>
</tr>
<tr>
<td>Technology as educational tool</td>
<td>97</td>
</tr>
<tr>
<td>Value of using ICT</td>
<td>241</td>
</tr>
<tr>
<td>Devices</td>
<td>327</td>
</tr>
<tr>
<td>ICT</td>
<td>38</td>
</tr>
<tr>
<td>Tools</td>
<td>64</td>
</tr>
<tr>
<td>Methodology</td>
<td>97</td>
</tr>
<tr>
<td>Positive aspects of app</td>
<td>26</td>
</tr>
<tr>
<td>Suggestions to improve app</td>
<td>17</td>
</tr>
<tr>
<td>Usability of the app</td>
<td>5</td>
</tr>
</tbody>
</table>
2.10.4 Validity and Reliability in the Qualitative Inquiry

As discussed in § 2.6.6, unless a researcher is able to show the audience that the procedures that were followed to ensure that his/her methods were reliable and his/her conclusions were valid, there is no point in trying to conclude a research dissertation (Silverman, 2007, p. 209). I used the same criteria to ensure validity and reliability in the qualitative inquiry as I used in the systematic literature review. A detailed description of the theoretical underpinnings is given in § 2.6.6.

The manner in which I have complied with the indicators as suggested by Given (2008, p. 753) and Creswell (2007, p. 206) in the qualitative inquiry is illustrated in Table 2.9.

**Table 2.9 Indicators of Credibility and Dependability in the Qualitative Inquiry**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodological coherence</td>
<td>The initial test interview was peer coded to ensure validity and reliability of the coding (§2.8.3.1) All data analysis was systematically done with the aid of ATLAS.ti™. The design of the app followed nine systematic and coherent steps in the design and development phase (§ 5.5.2)</td>
</tr>
<tr>
<td>Researcher responsiveness</td>
<td>The interpretation of the interview data was verified by two expert peers in the field of Mathematics education. Cohen’s Kappa was calculated to verify the interrater reliability (§ 2.8.3.2)</td>
</tr>
<tr>
<td>Audit trails</td>
<td>All procedures that were followed in the collection, analysis and description of the qualitative data were described in detail in § 2.8-2.10. The detailed analysis of the individual interviews was done in Chapter Four and the detailed analysis of the focus group interviews was done in Chapter Six.</td>
</tr>
<tr>
<td>Prolonged engagement</td>
<td>There was a period of nine months between doing the initial needs analysis of the teacher-students and the follow-up focus group interviews. In this time, myself and various other role players spent extensive time in conceptualising, developing and testing the mobile app, before meeting with the teacher-students for the second time.</td>
</tr>
<tr>
<td>Rich, thick descriptions</td>
<td>Chapters Four and Six present detailed analyses of the qualitative data. The actual words of participants were used to reinforce the analysis and findings. Reference is constantly made in these chapters to the conceptual framework from the literature review (Chapter Three) as well as the process that was followed in the research methodology of qualitative design-based research.</td>
</tr>
</tbody>
</table>

2.11 The Role of the Researcher

Denzin and Lincoln (2013, p. 8) describe the qualitative researcher as a “bricoleur,” a person who engages in the construction of something from a wide range of available things, an amateur who is able to do practical repairs of any kind (Given, 2008, p. 65; Gravemeijer & Cobb, 2013, p. 78). Denzin and Lincoln (2013, p. 11) are of the opinion that qualitative researchers should be proficient in performing a large number of assorted tasks which include interviewing and rigorous self-reflection, and should read widely about the many interpretive paradigms. Gravemeijer and Cobb (2013, p. 78) state that the way a design-based researcher goes about doing things resembles the way a “bricoleur” works. The qualitative researcher should understand that the research is an interactive process which is shaped by not only his/her own personal history, biography, gender, social class, race and ethnicity, but also those of the people in the setting (Denzin & Lincoln, 2013, p. 11). The researcher is the
primary instrument for collecting and analysing data (Creswell, 2013, p. 45; Merriam & Tisdell, 2016, p. 16).

When discussing the process of design-based research, Amiel and Reeves (2008, p. 35) discuss the liaison between researchers and practitioners. They suggest that researchers rarely engage directly with practitioners as far as the design process is concerned. The design-based research should start with negotiations between researcher and practitioner regarding the research goals. The practitioner’s role is to partner the researcher in establishing research questions and identify problems that need to be investigated (Amiel & Reeves, 2008, p. 35).

One of the requirements of a researcher in design-based research is that he or she should be “humble in approaching research by recognising the complexity of interactions that occur in real world environments and the contextual limitations of proposed designs” (Amiel & Reeves, 2008, p. 35). According to Plomp (2013, p. 43) the researcher needs to be adaptable, and the researcher needs to be adaptable in the following ways: in addition to being researcher, the researcher should be willing to take on the role of designer, advisor and facilitator; be tolerant with regard to role distinctions; and be willing to allow the study to be partially influenced by the role players (McKenney, Nieveen, & van den Akker, 2006, p. 84).

I am a lecturer in the Faculty of Education Sciences at the NWU, and work specifically with programmes that are delivered to in-service teacher-students, and specialise in the field of Mathematics education. I fulfilled a multi-faceted role in this research. Firstly I acted as researcher throughout the entire process. After negotiating with teacher-students and establishing what problem areas teacher-students (who acted as practitioners in this research) had in teaching Mathematics content to their learners, my second role, as a content specialist, was to design appropriate intervention in the form of a mobile app. The latter was based on the RME approach to assist the teacher-students to make the content which they teach to their learners more relevant and related to real life. The third role that I fulfilled in the study was to act as interviewer and facilitator of the teacher-students to establish what support-needs the teacher-students had in order to effectively implement the RME approach in their teaching, as well as to determine their perceptions about the mobile app as intervention. My fourth role was to design and refine guidelines appropriate for the application of the RME approach to be implemented with the aid of technology.

2.12 Summary of the Chapter

This chapter presented the research design and methodology for this study. The research questions formed the foundation of the method that was selected. I described my stance as an interpretivist and expressed the suitability of selecting to do a qualitative phenomenological study. I explicated the methodology of qualitative design-based research as well as the suitability thereof in this study. The
ethical considerations were taken into account. I detailed the description of the systematic literature review process as well as the qualitative inquiry. Concerning both aspects I discussed the rationale behind participant selection, site selection, data generation methods and the process of analysis. I also explored my role as researcher and discussed the trustworthiness of both the systematic literature review as well as the qualitative inquiry. Chapter Three presents the systematic literature review.
Chapter Three
Systematic Literature Review

3.1 Introduction

This chapter presents the review of the current literature with regard to the implementation of RME principles, aided by the use of ICT in Mathematics education. ATLAS.ti™ was used to analyse the literature in order to create themes for discussion and interpretation. Five themes emerged in this review which related to: (i) Mathematics, (ii) RME, (iii) ICT, (iv) Methodology, and (v) Role players. These themes guide the discussion in the chapter that follows. Figure 3.1 is an illustration from ATLAS.ti™ of the five main themes that emerged from the systematic literature review.

![Figure 3.1: Emerging Themes from the Systematic Literature Review](image)

Figure 3.1: Emerging Themes from the Systematic Literature Review

Figure 3.2 presents the conceptual framework for the systematic literature review and serves as a guide for the rest of Chapter Three.
3.2 Mathematics

3.2.1 Factors that influence teaching and learning

3.2.2 Mathematics Education

3.2.3 Approaches to the teaching of Mathematics

3.2.4 Meaningful learning

3.2.5 Teaching methods and strategies

3.2.6 Mathematical content

3.2.7 Learner aspects

3.3 Realistic Mathematics Education (RME)

3.3.1 RME theory

3.3.2 Characteristics of RME

3.3.3 Aspects of RME

3.3.4 Principles of RME

3.3.5 Advantages, disadvantages and recommendations for RME

3.4 Information and Communication Technology

3.4.1 Value of using ICT

3.4.2 ICT tools

3.4.3 Devices

3.4.4 ICT systems: Virtual Learning Environment (VLE)

3.4.5 ICT and RME

3.4.6 Challenges when working with ICT

3.5 Methodology: Design-based research

3.6 Role players

Figure 3.2: Conceptual Framework for the Systematic Literature Review
3.2 Mathematics

Mathematics is one of the main themes that arose from the systematic literature review as is illustrated in Figure 3.3.

![Figure 3.3: Mathematics as Theme from the Systematic Literature Review](image)

Mathematics is not just an abstract body of knowledge, but a subject that contains skills and a way of thinking that can be applied in numerous real life situations (Domazet, Baranović, & Matić, 2013). The teaching and learning of Mathematics is a complex undertaking, but should be connected to reality in order to make sense to learners (Cahyono, 2012). One of the main expectations of Mathematics is that it will develop rational thinking, orderliness and accuracy of expression, all of which can be applied in everyday life (Domazet et al., 2013).

3.2.1 Factors that Influence Teaching and Learning

The rapidly changing information society influences the role of learners and teachers (Gravemeijer, 2012). Future jobs require what Gravemeijer (2012) refers to as 21st century skills, which include “flexibility, critical thinking, problem solving, collaboration, and communication.” Gravemeijer (2012) emphasises the importance of addressing these demands by investigating educational practices that may nurture these goals. Heck et al. (2007) are of the opinion that digital assignments and diagnostic testing can increase motivation as well as performance in learners. Also, the use of real life contexts stimulate motivation because the relevance of Mathematics can then be seen in the real world (Risnawati, Kurniati, & Regita, 2014).

Mobile Learning (mLearning) is a field that is rapidly expanding and that affords new possibilities to improve learning, especially in a distance education (DE) environment (Kizito, 2012a). South Africa in particular is a suitable location to use mLearning in distance education due to its viability and affordability as opposed to web-based technology (Kizito, 2012a). Further research is required to determine how the mobile phone can effectively be used in testing in DE (Kizito, 2012a). The portability of mobile technology allows learners to work creatively and collaboratively (Zaranis et al.,
When used correctly, technology could promote critical thinking, improved problem solving skills and collaboration (Stols, 2012).

Various reasons are offered for poor performance in Mathematics. These include: when topics taught seem to be removed from learners' daily lives (Fauzan et al., 2013); inaccurate learning material; inadequate and out-dated teaching methods; poor forms of assessment and learners' anxiety about Mathematics (Widjaja & Heck, 2003); and learners' negative attitudes towards Mathematics (Widjaja & Heck, 2003). The difficulties that learners experience in Mathematics in later years are associated with the inadequate development of mathematical thinking in the initial years (Zaranis, 2014c).

### 3.2.2 Mathematics Education

An essential goal of Mathematics education is the adoption of fundamental mathematical knowledge, the development of basic mathematical literacy and the ability to solve problems (Domazet et al., 2013). Mathematics education is not about transferring a mound of mathematical knowledge to young people, but rather about fulfilling broader social goals (Domazet et al., 2013). It is important to remember that pedagogy should guide the process of designing digital technology, rather than technology itself (Drijvers, 2013). The technology needs to be rooted in an educational context (Drijvers, 2013).

Mathematics teachers are challenged to develop Mathematics education that is in line with the dynamic conceptions of symbolising and the development of meaning (Bakker et al., 2003). The role of the teacher is essential in understanding how to teach effectively with technology (Drijvers, 2012). A teacher needs to plan for productive whole-class discussions, which demands that the teacher needs to account for differences in students. Students are at different levels of mathematical understanding, and the teacher needs to highlight problem areas in such discussions that stimulate a higher level of understanding (Gravemeijer, 2012). Tasks should be designed in such a way that students are encouraged to develop their own Mathematics. The teacher needs to guide the process and should know when to further explore a topic or concept and when to cease to investigate a topic (Drijvers et al., 2013). Digital assessment and diagnostic testing can increase the motivation and performance of students in Mathematics education (Heck, Boon, & van Velthoven, 2008).

### 3.2.3 Approaches to the Teaching of Mathematics

The traditional teaching approach tends to dominate in many classrooms still today (Fauzan et al., 2013). This approach is characterised by teachers' who actively explain material and provide examples and exercises, while learners listen, write and perform the tasks requested by the teacher (Gravemeijer, 2012; Widjaja & Heck, 2003). There is very little room for discussion, interaction and communication (Widjaja & Heck, 2003), and learners normally do not get involved in problem solving and reasoning (Gravemeijer, 2012). The social norms of the traditional classroom dictate that the
teachers’ answers are always correct and that students should follow given procedures to reach correct answers, which are more important than reasoning (Gravemeijer, 2012). Learners are seldom given the opportunity to understand the rationale behind algorithms that are taught to them (Risnawati et al., 2014).

The traditional approach in teaching Mathematics has been labelled as a possible reason for the poor quality of Mathematics education in Indonesia (Fauzan et al., 2013; Widjaja & Heck, 2003). The reason for this is that most learners feel that they do not have the opportunity to learn significant Mathematics (Fauzan et al., 2013). Context problems in the traditional approach are used only as applications at the end of a section, rather than during the course of the teaching and learning process (Gravemeijer & Doorman, 1999).

Traditional teaching approaches tend to have a negative influence on learners, especially on their attitude towards Mathematics (Fauzan et al., 2013). Often in the traditional approach, learners work with problems that are not directly linked to school Mathematics, and they need to deal with unfamiliar situations and contexts (Mousoulides et al., 2007). Another consequence of traditional teaching is when students solve traditional word problems, high level cognitive and metacognitive processes are often absent (Mousoulides et al., 2007). The continuous change in Mathematics education is evident in the shift from traditional curricula to problem-oriented curricula (Widjaja & Heck, 2003).

A common thread of all alternative approaches is the belief that learning Mathematics should not be a process of assembling pieces of knowledge, but rather of cognitive growth (Gravemeijer & Doorman, 1999) and the development of core skills in learners (Heck, 2009). Reform from the traditional approach demands that curricula, teaching materials and assessment need to be adapted (Zulkardi, 2000). In essence, Freudenthal (1968), who is seen as the father of RME, opposes the traditional idea that the end result of the work of Mathematicians is the starting point for Mathematics education (Gravemeijer & Doorman, 1999).

Problem solving through modelling leads to the design of activities that allows for students to deal with non-routine problem situations that demand the development of important mathematical ideas that can be extended, explored and refined in other problem situations (Mousoulides et al., 2007). Technological tools create new prospects for problem solving in Mathematics (Doorman et al., 2007).

RME is a domain-specific instruction theory for the teaching and learning of Mathematics (Drijvers et al., 2013). The RME-based teaching and learning process promotes learner-centred learning (Fauzan et al., 2013). One of the cornerstones of RME is that learners are encouraged to not only receive information, but also question and process information (Widjaja & Heck, 2003), actively participate in the educational process and develop mathematical tools and insights (Drijvers et al., 2013). The RME approach can be used to address the shortcomings that the traditional approach presents, such as the remembering of facts and concepts that must be reproduced verbally, studying
computational aspects and applying formulas (Fauzan et al., 2013). RME does not aim to use abstract principles or rules in concrete situations (Widjaja & Heck, 2003).

Learners’ achievements tend to improve in experimental situations, which is common to the RME approach as opposed to traditional teaching (Fauzan et al., 2013; Zaranis, 2014a) and the learners become more independent and actively involved in the teaching and learning process (Fauzan et al., 2013; Fitzallen & Watson, 2014). Learners learn by experience, and not because of what they are told by the teacher (Gravemeijer, 2012). The structure of RME is such that learners gradually reorganise their thinking toward more abstract ideas and relate those ideas to the practical context of the situation (Fitzallen & Watson, 2014). Learners reconstruct solution procedures by using problems that have meaning in their reality (Drijvers & Doorman, 1996).

Teachers are key role players in bringing about change in education. Teacher training both pre-service and in-service is therefore essential (Zulkardi, 2000). Fauzan et al. (2013) found that teachers like to use the RME approach and that they are able to implement the approach as it is intended. They do however sometimes revert back to the traditional teaching approach, perhaps because they are not yet fully familiar with the RME approach (Fauzan et al., 2013).

In the RME approach, context problems have a central role in Mathematics teaching. They are used to support a reinvention process which allows learners to come to terms with formal Mathematics (Gravemeijer & Doorman, 1999). There is an increased focus on the utility of Mathematics in daily practice. It should not be seen as a ready-made product, the emphasis should rather be on the process of doing Mathematics (Zulkardi, 2000). Mathematics that is built on everyday perceptions is in line with the objectives of RME where formal mathematical knowledge can be created from situation specific reasoning (Doorman et al., 2008).

Development in technology encourages innovation in the teaching and learning of Mathematics (Cahyono, 2012). If technology is used correctly it can enhance teaching and learning, specifically in Mathematics (Stols, 2012; Zaranis, 2014c). More specifically, a technology enriched environment helps to improve the conceptual geometric growth of learners (Stols, 2012). ICT is a good catalyst to realise activity-based approaches to teaching Mathematics such as the RME approach (Widjaja & Heck, 2003). Computer-assisted learning can contribute in developing mathematical skills and can cultivate deeper conceptual thinking as compared to teaching in the traditional approach (Zaranis, 2014a, 2014c). Digital activities are particularly effective when they are designed to examine a specific problem or to teach a specific skill (Zaranis et al., 2013). New technological tools create new possibilities for problem-solving in Mathematics since new horizons can be explored (Doorman et al., 2007).

RME instruction theory links closely to the work of Van Hiele (Gravemeijer, 1999; Treffers, 1978). The Van Hiele theory identifies five discrete levels of Geometric development that are ordered and
progressive, that are not dependent on age but rather on a learners’ experience (Stols, 2012; Zaranis, 2014a). The Van Hiele theory has a significant influence on geometry education and can be used to measure the cognitive growth of students (Stols, 2012).

3.2.4 Meaningful Learning

The theory of RME can help to design activities that promote meaningful learning (Wijers, Jonker, & Drijvers, 2010). One way in which meaningful learning can be promoted in both formal and informal settings, is through playing games (Zaranis et al., 2013). The interaction between teacher and student and students with one another can provide them with opportunities to enhance their learning process through social interaction (Cahyono, 2012). This interaction also enhances reflection on work, engaging in explanations, justifying, agreeing and disagreeing, and questioning alternatives, which is an essential part of RME (Widjaja & Heck, 2003). Learners that are given the opportunity to discuss their own informal strategies in solving problems with the teacher and fellow pupils, have a greater opportunity to stimulate understanding than those who do not (Widjaja & Heck, 2003). Learning outcomes and learners’ understanding can be improved as a result of collaboration in learning (Cahyono, 2012). A crucial aspect in the learning process is when students are given the opportunity in the classroom to discuss their solutions and pose new problems (Bakker et al., 2003).

Tasks form an important aspect of meaningful learning. The execution of tasks should guide learners to acquire the concepts that they are required to master. When too few tasks are given, this might hinder the process of acquiring knowledge, while too many tasks can result in learners that are bored or exhausted (Widjaja & Heck, 2003). Tasks should be designed in such a way that they start by investigating problem situations that can be systematised and solved by the Mathematics that needs to be learned (Boon, 2006). The purpose of investigation tasks is to give students opportunities to improve their general competencies, deepen existing mathematical knowledge and become more adept in applying their knowledge and skills in practice (Heck, 2009).

Assessment should be in line with learners’ activities with technology, and should not be removed from the use of digital technology (Drijvers, 2013). Assessment can take on different forms such as writing an essay, doing an experiment, collecting data and drawing conclusions, designing exercises that can be used in a test, or designing a test for other learners in the classroom (Zulkardi, 2000).

3.2.5 Teaching Methods and Strategies

Learners’ attitudes have been noted to improve as a result of RME-based courses (Fauzan et al., 2013). The use of real world situations in school Mathematics is necessary to nurture a positive attitude towards the subject (Mousoulides et al., 2007).
Modelling activities that take place within real contexts can promote motivation and self-regulation (Mousoulides et al., 2007; Widjaja & Heck, 2003). Practical work can be done in groups and creates the opportunity for interaction between learners with each other and the teacher, where discussion and reflection about Mathematics and mathematical thinking is stimulated (Widjaja & Heck, 2003).

Dolk, den Hertog, and Gravemeijer (2002) describe reflection as a prerequisite for learning and constructing meaning and knowledge, specifically when dealing with learning from one’s own activities. This is important to remember in teacher education: beginner teachers need to be encouraged to reflect on their actions and experiences in the classroom (Dolk et al., 2002). Reflection and discussion can serve as encouragement to learners to do observation. When discussing what they have observed, they reflect on the strategies that they used to report and observe—this encourages better and deeper observations (Dolk et al., 2002).

### 3.2.5.1 Models

The term model refers to situation models and mathematical models that are generated by learners themselves (Zulkardi, 2000). Models are more than a visual representation of a piece of abstract Mathematics. They can be used to bridge the gap between abstract, informal strategies and real, formal Mathematics (Boon, 2006; Doorman, Drijvers, Gravemeijer, Boon, & Reed, 2013; Gravemeijer, 1999; Widjaja & Heck, 2003). Although modelling also necessitates computation and deduction processes, it is predominantly about focused description, explanation or conceptualisation (Mousoulides et al., 2007).

Gravemeijer (1999) explores a discussion about two types of models: a “model of” where reality is diminished into the form of a model (created after a concept is deliberated) and a “model for” where the same model can be utilised in other situations and in new realities. This implies that the “model of” informal mathematical thinking becomes a “model for” more formal mathematical reasoning (Doorman et al., 2013; Gravemeijer, 1999). The shift in the role of the model takes place alongside a shift in the learners’ thinking.

Activities that involve modelling are intrinsically social experiences since students often work together in small groups to develop a product that can be shared with others in the classroom (Mousoulides et al., 2007). Activities that require the production of models, can lead to significant forms of learning because they involve mathematizing which includes activities such as quantifying, coordinating, categorizing and systematizing (Mousoulides et al., 2007). Activities such as these are intended to disclose the way in which students think about real life situations that can be modelled through Mathematics (Mousoulides et al., 2007). The creation of a model is often a cyclical process (Mousoulides et al., 2007).
The roles of context problems and modelling are closely intertwined (Gravemeijer & Doorman, 1999). When modelling activities are set within realistic contexts, this allows for learners to make use of multiple interpretations and approaches, thereby promoting intrinsic motivation and self-regulation (Mousoulides et al., 2007). It is important to work with and study modelling of intricate systems that occur in real life situations, even from the early grades, because such models are essential aspects of knowledge that need to be emphasised in teaching and learning. This is especially important for learners preparing to work in fields such as Mathematics, Science and Technology (Mousoulides et al., 2007). By using modelling, learners are able to reason with a model of the problem, but also think about how they are to act in the real life situation (Andresen, 2007). Eventually, learners will not need the support of a model for more formal mathematical reasoning (Andresen, 2007).

Models emerge from learners’ activities. As learners reason, models are generated while discussions and activities take place in the classroom (Doorman et al., 2008). Learner sense-making can be enhanced when using realistic modelling problems in Mathematics. This also helps to nurture a positive attitude towards Mathematics (Mousoulides et al., 2007). The descriptions, explanations and justifications that learners make use of form an integral part of the models that they produce (Mousoulides et al., 2007).

Models clearly play a different role in RME than in the more conventional teaching approaches (Gravemeijer, 1999). In the traditional teaching approaches, models are most often used as didactic embodiments of the formal Mathematics that is taught. This means that the formal Mathematics is concretized in order to be made more tangible for the students (Gravemeijer, 1999). The RME philosophy advices that instruction should be designed to use models and diagrams to build learners’ reasoning gradually from the concrete to the abstract, thereby reinforcing learners’ reasoning (Fitzallen & Watson, 2014). For RME to work, learners need to know how to model new situations (Boon, 2006). Models are able to support mathematization of the intended concepts (Doorman et al., 2008). The models should be generalised to develop into entities of their own, which then can be used as models for mathematical reasoning (Doorman et al., 2008; Widjaja & Heck, 2003).

Virtual manipulations which are facilitated by computer software are similar to physical manipulations which means that ICT can effectively support the learning process, especially in Mathematics (Zaranis et al., 2013). Technology can successfully enhance the meaning of symbolic information by making it more visual and more easily manipulated, which makes the content more accessible (Gravemeijer, 2012).

### 3.2.5.2 Strategies

RME focuses on the development of abstract thinking (Fitzallen & Watson, 2014) by using context problems to encourage students to develop situation-specific representations and strategies (Doorman et al., 2008). The RME approach can assist in creating a positive classroom climate which
allows for interaction and collaboration (Fauzan et al., 2013; Wijers et al., 2010). Learners should adopt the necessary classroom social norms to suit an inquiry-oriented classroom culture (Gravemeijer, 2012). Learners enjoy performing experiments during lessons rather than just listening to the teacher and doing written exercises (Widjaja & Heck, 2003). This tends to create a livelier, noisier and messier classroom, but does provide a more enjoyable atmosphere for teachers and learners to work in, and learners tend to be more enthusiastic about the work (Widjaja & Heck, 2003; Wijers et al., 2010).

An inquiry-oriented classroom creates the opportunity for learners to explain and justify their solutions, to try and understand other learners’ reasoning and to ask questions if they do not understand (Gravemeijer, 2012). Apart from these inquiry-based norms, learners should also be prepared to solve mathematical problems, discuss solutions and deliberate about the core concepts (Gravemeijer, 2012). An interactive classroom allows for learners to discover things for themselves, talk actively with one another and with the teacher, and to be more aware of their own mathematical thinking (Widjaja & Heck, 2003).

It is important that teachers are willing to adapt their role in the classroom by moving towards more learner-centred learning (Widjaja & Heck, 2003). Teachers often are required to improve their skills in conducting class discussions, addressing questions that challenge learners and encourage them to think critically (Widjaja & Heck, 2003). The shift from the more traditional teaching approach to a more inquiry-driven approach means that cooperation, problem solving and metacognition are promoted (Gordon et al., 2012; Mousoulides et al., 2007).

3.2.6 Mathematical Content

According to Gravemeijer (1999), one of the reasons that learning Mathematics has been branded as difficult is that the gap between everyday life and formal Mathematics is vast. Formal Mathematics should grow out of learners’ activities and should not be seen as something abstract and removed from reality (Gravemeijer, 1999). Within the RME approach, learners are expected to develop formal Mathematics by mathematizing their informal mathematical activities (Gravemeijer, 1999).

The RME approach distinguishes itself from other approaches in that it surpasses the contrast between informal and formal knowledge. The design of a hypothetical learning trajectory (HLT) can assist students in reinventing formal Mathematics (Gravemeijer & Doorman, 1999). Ideally the learning trajectory develops in such a way that the formal Mathematics surfaces in the activities that the students do (Gravemeijer & Doorman, 1999; Heck et al., 2008). In the RME philosophy, different Mathematics topics should be integrated in one curriculum. This promotes the idea of an integrated view of Mathematics, and sanctions flexibility to connect sub-divisions of the curriculum with each other and also to connect abstract Mathematics to meaningful problems in the real world (Widjaja & Heck, 2003).
The intention of the RME approach is that students should experience formal Mathematics and informal Mathematics in the same way (Gravemeijer, 1999). What students ultimately understand of formal Mathematics should remain associated with their understanding of the everyday phenomena that they experience (Gravemeijer & Doorman, 1999).

In the RME approach, it is essential that formal Mathematics can be developed as an instrument for solving real problems for the students (Boon, 2006). Real contexts that are meaningful to learners should be used as a starting point for their learning. Situations in which concepts appear in reality should be used as a starting point for concept formation and should lead to more formal Mathematics (Doorman et al., 2013; Widjaja & Heck, 2003). Technology can also assist in bridging the gap between formal and informal Mathematics. Mathematical applets are able to visualize mathematical concepts and explore context situations (Heck et al., 2008).

It is important in the RME approach that Mathematics teaching is a process in which students develop and apply mathematical concepts in real life problem situations (Domazet et al., 2013). The development of algebraic understanding and skills is an important topic in Mathematics education; however it is an obstacle for many students (Heck et al., 2007). One of the reasons for this is that algebraic manipulations are often carried out in a superficial way where rules are used but are not meaningfully connected to the underlying concept (Heck et al., 2007). Various programmes have been designed and developed to help learners practice algebraic skills in ways that make sense (Heck et al., 2007).

Geometry is often the most difficult topic in school Mathematics for learners and teachers (Fauzan et al., 2013; Stols, 2012). Learners’ poor performance in Geometry, as well as their negative attitude to Geometry is a challenge in many classrooms (Fauzan et al., 2013). Making use of real contexts and data that students can relate to is essential in statistics education (Fitzallen & Watson, 2014). Technology can provide many options for representing graphical data which can help improve student learning in statistics (Fitzallen & Watson, 2014). The appropriate use of technology can help students to understand mathematical concepts more effectively (Zaranis, 2014b). According to the principles of RME, learners should mathematize everyday subject matter as well as their own mathematical activity (Gravemeijer & Doorman, 1999).

3.2.7 Learner Aspects

The theory of RME is predominantly about knowledge construction (Gravemeijer, 1999). Activities based on the RME approach allow for learners to build their own mathematical knowledge (Gravemeijer, 1999). When designing activities, teachers should be sensitive about where their learners are in terms of their anticipated learning so that activities can be based on ideas that are less sophisticated than the Mathematics being taught (Kizito, 2012a). Through interaction with each
other, students can enhance the understanding of mathematical concepts and their application in real life, which is an important characteristic of RME (Cahyono, 2012).

Social interaction, one of the five tenets or characteristics of RME, is an essential part of RME (Cahyono, 2012; Widjaja & Heck, 2003; Zaranis, 2014a, 2014c; Zulkardi, 2000). The aim of RME is to allow learners to consider the knowledge that they acquire as knowledge for which they are responsible. For this to happen, certain social norms should be in place, such as “you should not guess the answers,” and “you need to work things out yourself” (Gravemeijer & Doorman, 1999). The learning process is enhanced by social interaction in the form of discussions, between learners and learners and learners and teachers (Cahyono, 2012; Widjaja & Heck, 2003). Interaction can promote the understanding of mathematical concepts and the way in which those are applied in real life (Cahyono, 2012). Modelling activities are essentially social experiences because learners work together in groups to produce something that can be shared (Mousoulides et al., 2007; Zaranis, 2014a).

Digital learning activities can inspire learners to work collaboratively (Zaranis et al., 2013). A learning environment that includes a mobile device has the potential to encourage collaborative work in learners (Kizito, 2012a; Zaranis et al., 2013). A virtual learning environment (VLE) provides an opportunity for learners to interact with one another and with the teacher (Cahyono, 2012)

3.2.7.1 Learner Understanding

By allowing learners to use informal strategies to solve problems, and allowing for discussion with fellow pupils and the teacher, the process of understanding is stimulated (Widjaja & Heck, 2003). When learners apply their mathematical knowledge in a tangible context and in a meaningful way, it leads to a deepening of their knowledge and consolidation of the concepts involved (Heck, 2009).

In RME, the holistic view of learning is emphasised where students’ needs are addressed and the realisation of educational goals and purposes are facilitated (Fitzallen & Watson, 2014). RME focuses on the development of abstract thinking which assists in relating ideas in the practical context of a situation (Fitzallen & Watson, 2014). The use of the RME approach has the potential to improve learners’ understanding of Mathematics (Cahyono, 2012). A benefit of using the RME approach is that learners can use the new knowledge and skills that they acquired from one lesson in the lessons that follow (Fauzan et al., 2013).

Educational technologies provide alternatives for presenting data through different representations, thereby improving student learning (Fitzallen & Watson, 2014). Computer-assisted learning can augment the development of mathematical skills and can encourage a deeper perceptual aptitude for learners (Zaranis et al., 2013). Tools influence the way in which students make sense in Mathematics (Doorman et al., 2008)
3.2.7.2 Learner Reasoning

Poor performance of learners, especially in international testing, can possibly be attributed to the instructional setting (Widjaja & Heck, 2003). Learners’ own constructions are an important part of the learning process because they form the basis of classroom discussions and interactive reflection (Wijers et al., 2010). Learner achievement improves as a result of the intervention of an RME course (Fauzan et al., 2013). Learners’ reasoning can be reinforced by using models, diagrams and other imagery (Fitzallen & Watson, 2014).

The interactive classroom encourages learners to explore things for themselves, talk more actively and become more conscious of their own mathematical thinking (Widjaja & Heck, 2003). When working with symbols, it is important for teachers to remember that students do not always have the mathematical background to interpret those symbols correctly. The teacher should explain to students what can be seen, how it can be interpreted and how they need to reason with those symbolic representations (Bakker et al., 2003).

3.3 Realistic Mathematics Education (RME)

Figure 3.4 represents the theme of RME with its sub-themes as categorised in the systematic literature review.

![Figure 3.4: Realistic Mathematics Education (RME) as Theme from the Systematic Literature Review](image)

According to Freudenthal (1991), students should be given the opportunity to reinvent Mathematics through a process of mathematization (Cobb et al., 2008; Doorman et al., 2008; Doorman et al., 2013; Gravemeijer, 1999), where they formalize their informal understandings and intuitions (Cobb et al., 2008) and are supported in re-creating or reinventing Mathematics (Doorman et al., 2013). The
The central idea of Realistic Mathematics Education (RME) is that instruction is designed in which everyday situations and mathematical activities are mathematized. This allows for learners to reinvent Mathematics and thereby realise a better understanding of the subject (Kizito, 2012a). One of the aims of RME is to provide learners with the opportunity to consider the knowledge that they acquire as their own (Boon, 2006).

### 3.3.1 Realistic Mathematics Education Theory

RME, a teaching and learning theory in Mathematics education (Zulkardi, 2000), was based and developed on Freudenthal's view of Mathematics as a human activity (Cahyono, 2012; Cobb et al., 2008; Dolk et al., 2002; Domazet et al., 2013; Doorman et al., 2008; Doorman et al., 2013; Freudenthal, 1991; Kizito, 2012a; Perez, 2012; Widjaja & Heck, 2003; Zaranis, 2014c; Zulkardi, 2000). Various studies in Mathematics education have made use of the theoretical framework based on the RME approach (Andresen, 2007; Heck et al., 2007; Kizito, 2012a; Zaranis, 2014a).

RME is a foremost view on the learning of Mathematics in The Netherlands (Doorman et al., 2007). The main aim of the Freudenthal Institute is to do research and curriculum development so as to promote innovation and improve Mathematics education (Boon, 2006). The RME principles of discovering learning in a real context, where Mathematics is seen as a human activity, and where students make sense through participation in mathematical representation, is greatly treasured (Heck, 2009). The RME theory is a vision or philosophy of Mathematics that is being developed in an on-going process (Gravemeijer, 1999; Zaranis, 2014a). It is not fixed, but involves a process of experimentation, analysing and reflecting and is constantly under construction (Gravemeijer, 1999). RME develops in an iterative process of expansion, adjustment and refinement (Gravemeijer, 1999) and relates to the work of Van Hiele (Gravemeijer, 1999).

RME is more than simply situating Mathematics in a real world situation; instead the instructional tasks should draw on realistic situations as a foundation for students' mathematization. The activities should be designed in such a way that students can systematise their activity within the realistic context to reinvent significant Mathematics (Stephan & Akyuz, 2014).

### 3.3.2 Characteristics of Realistic Mathematics Education

Various researchers highlight the five tenets or characteristics of RME (Cahyono, 2012; Dolk et al., 2002; Drijvers & Doorman, 1996; Widjaja & Heck, 2003; Zulkardi, 2000), namely:

i) the use of contextual problems

ii) the use of models

iii) the use of student contribution

iv) interactivity (among pupils and between pupils and teacher)

v) intertwining of learning strands.
Real contexts that are meaningful and natural to pupils are important to use as a starting point for learners’ learning (Boon, 2006; Dolk et al., 2002; Widjaja & Heck, 2003; Zulkardi, 2000). These contexts can be concrete or abstract and should be explored to develop intuitive notions that form the foundation of concept formation (Stols, 2012). This allows them to engage with the situation immediately. It is imperative that the instruction should not start with the formal Mathematics and end with the application in a real context, but rather that the contexts should be used as anchors for the formation of concepts (Widjaja & Heck, 2003). When using personalised contexts, where the meaningfulness of the context increases, students’ solution of word problems improve and student motivation increases (Gravemeijer & Doorman, 1999).

Using models or bridging by vertical instrumentation is an important aspect in RME. Learners should develop and use models when solving problems as a bridge between what is abstract and what is real. Initially the model is a representation of what is familiar to learners, later by generalization and formalization, it becomes an object on its own that is used for mathematical reasoning and can assist in developing sophisticated mathematical concepts (Dolk et al., 2002; Widjaja & Heck, 2003). Learners should be given the opportunity to create concrete objects which assists in informal problem solving strategies. Teachers should design activities and instructional material in such a way that learners are guided through a bottom-up reinvention process (Widjaja & Heck, 2003).

Interaction in the classroom is an important aspect in RME since it encourages discussion and collaboration, both important aspects when reflecting on the work. The kind of interaction that takes place is explaining, justifying, agreeing and disagreeing, questioning alternatives, and reflecting (Widjaja & Heck, 2003). The integration of different topics in Mathematics into one curriculum is imperative in the RME philosophy. Learners should have a cohesive view of Mathematics as well as the flexibility to associate content with other disciplines or domains and also to problems in the real world (Widjaja & Heck, 2003).

With the introduction of RME principles in the classroom, interactivity can be promoted as learners take more responsibility for their learning (Widjaja & Heck, 2003). The classroom is inclined to become more energetic as learners do experimental work and are involved in discussions and debates (Widjaja & Heck, 2003). The open computer learning environment can assist with interactivity as learners explore on their own, and tend to be more aware of their own mathematical thinking (Widjaja & Heck, 2003).

A high quality RME-based course requires three quality criteria, namely: validity (content validity where the intervention includes new knowledge, and construct validity where interventions are linked to each other); practicality which means that teachers and learners consider the interventions to be engaging in normal conditions; and effectiveness which refers to the experiences and outcomes that are consistent with the proposed aims (Cahyono, 2012; Fauzan et al., 2013).
In a study that investigated the teaching of triangles and circles, with and without technology, teaching intervention was based on the characteristics of the theory of RME and the van Hiele model. These characteristics include: the introduction of a problem using a realistic context; the main objects of the problem are identified; social interaction and teacher intervention to refine the models of the problem; encouraging the process of reinvention; and focusing on the connections and aspects of Mathematics in general (Zaranis, 2014a).

3.3.3 Aspects of Realistic Mathematics Education

3.3.3.1 Mathematics as a Human Activity

Various researchers refer to Freudenthal’s work (Freudenthal, 1971) when discussing his view of Mathematics as a human activity (Cahyono, 2012; Cobb et al., 2008; Dolk et al., 2002; Domazet et al., 2013; Doorman et al., 2008; Freudenthal, 1971; Kizito, 2012a; Perez, 2012; Widjaja & Heck, 2003; Zaranis, 2014c; Zulkardi, 2000), rather than a man-made system (Kizito, 2012a). Mathematics must be connected to reality (Cahyono, 2012; Widjaja & Heck, 2003; Zulkardi, 2000), where learning is viewed as a process within a social context (Perez, 2012) that can be used as a source for mathematization (Widjaja & Heck, 2003). Students should be supported (Doorman et al., 2013) and encouraged to reinvent Mathematics (Cobb et al., 2008; Dolk et al., 2002; Doorman et al., 2008).

According to Freudenthal (1968), in order for Mathematics to be of human value, it should be taught so as to be useful. This means that it should be closely related to reality, close to children and relevant to society (Zaranis, 2014a). Students should be able to understand the concepts of Mathematics and its application in the real world (Cahyono, 2012).

3.3.3.2 Mathematization

Freudenthal’s view of Mathematics as a human activity (Freudenthal, 1968) suggests that Mathematics can be used as a source for mathematization (Widjaja & Heck, 2003), which means organising matter from a mathematical perspective (Gravemeijer & Doorman, 1999). The process of developing mathematical concepts and ideas that originate in a concrete situation in the real world is known as mathematization (Cahyono, 2012; Freudenthal, 1968; Zulkardi, 2000). The process forces students to explore the situation, find and identify relevant Mathematics, schematize and visualize, in order to develop a model which leads to the Mathematics concept. They can then apply mathematical concepts to new areas of the real world, and so reinforce the concept (Zulkardi, 2000).

Students should learn Mathematics by mathematizing subject matter from reality and their own mathematical activity (Freudenthal, 1968; Gravemeijer, 1999). Freudenthal highlights the importance of mathematical activities that are taken from reality, that consist largely of organizing, mathematizing
subject matter (Cahyono, 2012; Freudenthal, 1968). He believes that mathematizing can comprise the mathematizing of both subject matter from real life situations as well as mathematical subject matter (Freudenthal, 1968; Gravemeijer & Doorman, 1999).

Treffers (1978) differentiates between two kinds of mathematization, namely horizontal and vertical mathematization (Freudenthal, 1991; Treffers, 1978; Widjaja & Heck, 2003; Zulkardi, 2000). Horizontal mathematization refers to the modelling of experientially real situations into Mathematics and vice versa (Freudenthal, 1991; Treffers, 1978; Widjaja & Heck, 2003). This is the process in which learners convert problem situations that they perceive as real into some form of Mathematics. They use and create mathematical tools to organise and solve mathematical problems located in real life situations (Freudenthal, 1991; Treffers, 1978; Widjaja & Heck, 2003; Zulkardi, 2000). Vertical mathematization refers to the process of accomplishing a higher level of abstraction within Mathematics (Widjaja & Heck, 2003). This refers to reorganization within the mathematical system, such as finding short cuts, generalizing methods, and making connections between concepts (Freudenthal, 1991; Treffers, 1978; Widjaja & Heck, 2003). Freudenthal (1991) describes the two as follows: horizontal mathematization moves from the world of life to the world of symbols, while vertical mathematization means moving within the world of symbols (Widjaja & Heck, 2003). Progressive mathematization, also known as vertical and horizontal mathematization, allows learners to rediscover the knowledge, insight and mathematical procedures (Cahyono, 2012).

With regard to mathematization, Treffers (1978) divides Mathematics education into four types, namely the mechanistic, empiristic, structuralist and realistic approach. Firstly, in the mechanistic or traditional approach, horizontal and vertical mathematization are seldom or never used. Secondly in the empiristic approach, students are faced with situations in which they have to do horizontal mathematization, but do not need to produce a model or formula. Thirdly, in the structuralist approach, which is based on set theory, flowchart and games, the approach relates to horizontal mathematization in a created world, and is not linked to the real world. Finally, in the realistic approach, a real world situation is taken as the starting point for learning Mathematics (it is explored using horizontal mathematization), students then organize the problem, identify regularities and relations and by using vertical mathematization, they develop concepts (Freudenthal, 1991; Treffers, 1978; Zulkardi, 2000).

Zulkardi (2000) distinguishes between conceptual mathematization and applied mathematization. Conceptual mathematization is the process of extracting the applicable concept from a real situation. The process compels students to explore the situation, identify the relevant Mathematics, systematise and visualise to develop a model resulting in a mathematical concept. Applied mathematization occurs when the concept is applied to new areas of real life in which the concept is supported and reinforced (Zulkardi, 2000).
In the RME approach, learners are given the opportunity to create concrete objects that can be used as a point of departure for mathematization and the subsequent formalization of the informal strategies (Gravemeijer, 1999; Widjaja & Heck, 2003). Activities that stimulate the generation of a model can lead to imperative forms of learning because they involve mathematization (Mousoulides et al., 2007). The mathematization occurs by counting, dimensioning, classifying, algebraising, and organising different objects, associations, actions, arrangements and regularities (Mousoulides et al., 2007).

The process of solving contextual problems starts with the real world problem which the learner then will mathematize, reflect on the problem, do abstraction and formalisation and then return to the real world at the end of the process (Cahyono, 2012). The real world should be truly authentic for mathematization to be most effective (Doorman et al., 2007). Educational designs should be based on carefully chosen real world situations that can easily be mathematized (Boon, 2006). Software is an ideal means to stimulate such situations to recall familiarities and extend them with new ones (Boon, 2006).

3.3.3.3 The Use of Tasks in Realistic Mathematics Education

Tasks are defined as problematic situations that are experientially real for students. This means that they can experience the problem that they encounter, as real (Stephan & Akyuz, 2014). They need to be appropriate for mathematization (Stephan & Akyuz, 2014) and should be designed in such a way that students are encouraged to reinvent key mathematical concepts (Stephan & Akyuz, 2014).

Teachers involved in the design of instructional material participate in various ways: anticipating supportive mathematical imagery; creating challenging formative assessment; making use of their mathematical knowledge to change and improve the instructional sequence; and working and revising tasks that were already created (Stephan & Akyuz, 2014). Apart from the instructional sequence itself, which is considered the most important aspect by teachers in guiding their actions, lesson imaging is also an important aspect. Lesson imaging allows teachers to envision how students will solve problems, and how this can be exploited to result in powerful mathematical discussions, where objectives can be met (Stephan & Akyuz, 2014). Collaboration plays a crucial role in teachers’ practices in their own success in the classroom (Stephan & Akyuz, 2014).

3.3.3.4 Hypothetical Learning Trajectory (HLT)

The hypothetical learning trajectory (HLT) refers to the consideration of the learning goal, the tools they will use, if technology is involved (Perez, 2012; Simon, 1995), the learning activities, and the thinking and learning in which students might engage (Perez, 2012; Simon, 1995). Originally, HLTs were designed for short teaching cycles of one or two lessons, but later were extended to sequences
of lessons varying from eight to twenty lessons (Bakker et al., 2003). The concept of HLT is a highly flexible instrument suitable when discussing different aspects of teaching and learning (Perez, 2012).

The development of an HLT involves the design of instructional activities that relate to the assessment of the initial level of understanding, the formulation of the end result and the envisaged mental activities of the students (Bakker et al., 2003). HLTs allow for students to reinvent formal Mathematics (Gravemeijer, 2012). They are designed in such a way that the formal Mathematics emerges from the mathematical activity that the students are involved in (Gravemeijer, 2012). The HLT should not have a rigid structure and should not expect students all to follow the same learning trajectory at the same speed; the HLT should represent a broader learning route (Bakker et al., 2003). The development of the HLT and the design of instructional activities are closely related.

The HLT guides the design of the instructional activities, however within the design process, the HLT may be reconsidered and adapted (Bakker et al., 2003). The HLT will normally be improved after a teaching experiment, based on classroom experiences. Thereafter, a new teaching cycle is started, and within design-based research, a new research cycle is also started (Bakker et al., 2003). An aspect of HLT that challenges designers is that each tool, although seemingly similar, can have varying effects on how students interact in the activity (Perez, 2012). What is important is that students’ investigations, reasoning and solutions are shared, discussed and generalised to other problem situations (Boon, 2006).

The HLT deals with a small number of instructional activities and is tailored to the teacher’s own classroom at any given moment (Gravemeijer, 1999). The HLT is important to teachers at the start of a project to help in orientating them (Stephan & Akyuz, 2014). The hypothetical nature of these learning trajectories implies that teachers need to examine students’ reactions to determine whether the actual learning trajectory corresponds with what was intended (Bakker et al., 2003; Gravemeijer, 2012). As a result, teachers should interpret and create new instructional activities (Gravemeijer, 2012), depending on whether the conjectures can be verified or should be rejected (Bakker et al., 2003).

The HLT is a suitable research instrument in observing the development of instructional design activities and the associated hypotheses within design-based research (Bakker et al., 2003). As students’ mental activities are emphasised, the expected results are motivated (Bakker et al., 2003). If an HLT is designed where technology is integrated, the designer ought to be knowledgeable about the tool and also how teachers and students perceive the use of technology in a learning activity (Perez, 2012).
3.3.3.5 Design of Activities

When designing learning activities, it is important to remember that the activity should encourage the students' work with Mathematics (Andresen, 2007). Designers should make use of their domain specific knowledge, teaching experience and their view on the teaching and learning of the topic when designing activities for the students (Bakker et al., 2003). The design of instructional activities is an essential part of executing a teaching experiment (Bakker et al., 2003). Instructional tasks should be designed so that students are given the opportunity to reinvent important mathematical concepts (Stephan & Akyuz, 2014). The development of an HLT is related to designing instructional activities (Bakker et al., 2003). Unlike with HLT's which are hypothetical, when instructional activities are performed, the teacher should look for evidence of whether the conjectures can be verified or not (Bakker et al., 2003).

3.3.3.6 Real Life Contexts

Context problems are defined as problems in which the problem situation is experientially real to the student (Gravemeijer & Doorman, 1999; Widjaja & Heck, 2003). Solving problems in realistic contexts, which students recognise as relevant and real, and which offer opportunities to develop situation-specific reasoning and tentative representations for organizing repeated calculations, plays a crucial role in the RME approach from the start (Boon, 2006; Doorman et al., 2008; Gravemeijer & Doorman, 1999; Stephan & Akyuz, 2014). In RME learners have the opportunity to learn Mathematics based on activities they experience in their everyday lives (Fauzan et al., 2013).

The students' understanding of the formal Mathematics should be entrenched in their understanding of the everyday-life occurrences (Gravemeijer & Doorman, 1999). Authentic contexts and real data that students can relate to are especially important in statistics (Fitzallen & Watson, 2014). This allows for optimal learning opportunities (Fitzallen & Watson, 2014). Students' solutions to word problems improve when personalized contexts are used. This enhances the meaningfulness of the context and can increase motivation (Gravemeijer & Doorman, 1999). Didactical phenomenology presents students with phenomena that need to be organised by mathematical structures. These phenomena can best be generated by meaningful contexts from real life which should occur naturally and with meaning (Bakker et al., 2003).

Even a pure Mathematics problem can be considered a context problem, if the Mathematics involved is experientially real for the student (Gravemeijer & Doorman, 1999). Context problems can act as anchoring points for students to learn and reinvent Mathematics (Gravemeijer & Doorman, 1999; Stephan & Akyuz, 2014; Widjaja & Heck, 2003), and should be selected so that they provide students with the opportunity to develop situation specific strategies (Bakker et al., 2003; Doorman et al., 2008). Well selected context problems provide opportunities for students to develop informal, context-specific solution strategies (Gravemeijer & Doorman, 1999; Widjaja & Heck, 2003).
Context problems form the foundation for progressive mathematization (Gravemeijer & Doorman, 1999) and should be observed as natural and meaningful in order to offer a foundation for the mathematization (Bakker et al., 2003). Solving contextual problems starts from real life problems that students mathematize and reflect on, form abstractions and formalise, then return to the real world at the end of the process (Cahyono, 2012).

Context problems are rooted in students’ reality, yet by solving these context problems students are able to expand their own reality (Gravemeijer & Doorman, 1999). They allow for students to develop informal, context-specific models and strategies for solving the problems, which can later be formalized and generalized to establish a process of progressive mathematization (Doorman et al., 2008) and give students the opportunity to develop representations and strategies that relate to the situation (Doorman et al., 2008).

In the RME approach, models should be grounded in the contextual problems that students should solve (Gravemeijer, 1999). Context problems that offer students opportunities to develop situation-specific strategies should be chosen. The models that develop from these contexts emerge from the students' activities (Gravemeijer & Doorman, 1999). Modelling activities should take place in a situation that is experientially real for the students (Andresen, 2007; Doorman et al., 2008). Mathematical ideas should be fixed in meaningful real world contexts and are developed by students as they work on problems (Mousoulides et al., 2007). These ideas should be close to children’s reality and should be relevant to everyday situations in life (Zulkardi, 2000).

Context problems are designed to support the reinvention process that gives students an opportunity to come to terms with formal Mathematics (Gravemeijer & Doorman, 1999). Activity sheets are one way in which students can be guided to advance from informal to more formal activities ( Heck et al., 2008). RME not only uses contexts in the teaching and learning of Mathematics, but attaches substantial significance to Mathematics teaching as a process in which students develop and apply mathematical concepts and tools in realistic contexts (Domazet et al., 2013). The RME approach uses real world contexts in problem-solving to encourage motivation in students because the Mathematics is linked to the real world (Fauzan et al., 2013; Risnawati et al., 2014).

Realistic contexts are vital in not only developing sophisticated symbols, but also in developing meaning within the symbol (Bakker et al., 2003). Lessons should be designed to allow learners to use their knowledge of the context to support their thinking ( Fitzallen & Watson, 2014). Instruction that is designed where everyday situations and mathematical activities are mathematized, assists students in reinventing Mathematics, and therefore achieving a better understanding of the subject (Kizito, 2012a). Many learners dislike Mathematics because they do not learn something useful and significant to them (Fauzan et al., 2013).
Digital technology should be entrenched in a context that is comprehensible and in which the technology is integrated in a natural way (Drijvers, 2013). It should be simple, attractive, easily accessible and close to the student’s life (Risnawati et al., 2014). Real world situations should be chosen in such a way that software can simulate the situations which allow for mathematization to take place (Boon, 2006). ICT tools allow learners to utilise new learning platforms and also assist them in realising new knowledge through activities related to real life scenarios (Zaranis et al., 2013). ICT can assist in realising realistic analysis by allowing for the following: collecting good quality real-time data; analysing and visualising the data; doing otherwise complex calculations; building and using computer models; comparing results and producing reports (Heck, 2009). The graphics calculator can stimulate the use of realistic contexts (Drijvers & Doorman, 1996) and the mobile phone has the potential to allow students to engage in real, authentic tasks (Kizito, 2012a). Over and above the use of contexts in Mathematics teaching and learning, it is imperative in the RME approach that Mathematics is taught as a process in which students develop and apply Mathematical concepts and tools in problem situations with a realistic context (Domazet et al., 2013).

3.3.4 Principles of Realistic Mathematics Education

The three principles or key heuristics of RME that inform the design of instructional sequences are: guided reinvention or progressive mathematization, didactical phenomenology and emergent modelling (Andreasen, 2006; Bakker et al., 2003; Cahyono, 2012; Dolk et al., 2002; Drijvers et al., 2013; Stephan & Akyuz, 2014; Widjaja & Heck, 2003). These three principles should guide the design process to ensure that meaningful problems are used to foster students’ cognitive development (Bakker et al., 2003). The instructional designer requires knowledge of the suitable design principles as well as their application in different context-specific situations (Doorman et al., 2013).

3.3.4.1 Guided Reinvention

The principle of guided reinvention (or progressive mathematization (Andreasen, 2006)), the first instructional design principle in RME (Gravemeijer, 1999), implies that learners should be given the opportunity to develop their own Mathematics (Bakker et al., 2003; Drijvers et al., 2013; Gravemeijer, 1999; Gravemeijer & Doorman, 1999). They should be allowed to experience a process which is similar to that by which a given mathematical topic was invented (Drijvers et al., 2013). In guided reinvention, learners will devise informal strategies to solve problems that may be formalized and generalized to establish a process of further abstraction (Doorman et al., 2008). The process requires guidance from the teacher who can help to direct the progression in a sensible manner (Drijvers et al., 2013).

In guided reinvention, Freudenthal (1991) believes that the emphasis should be on the character of the learning process, rather than on the invention itself (Gravemeijer & Doorman, 1999). Learners
should consider the knowledge that they acquire as their own, and should take responsibility for that knowledge (Gravemeijer & Doorman, 1999).

Guided reinvention encompasses reconstructing the expected way of developing a mathematical concept from a given problem situation (Bakker et al., 2003). The process begins with the mathematizing of real life subject matter, and leads to reinvention where students mathematize their own mathematical activities (Gravemeijer, 1999; Gravemeijer & Doorman, 1999). Formal Mathematics develops from students’ activities (Gravemeijer, 1999). Guided reinvention can involve the development of new problem solving strategies which are necessary to solve tasks which cannot be solved with the existing strategies (Drijvers et al., 2013). Guided reinvention provides a manner in which to bridge the gap between formal and informal Mathematics (Gravemeijer & Doorman, 1999). This process, which provides students with the opportunity to reinvent Mathematics, surpasses the contrast between Mathematics as an activity and Mathematics as a body of knowledge (Gravemeijer, 1999).

Context problems play a key role in the reinvention process. Well-selected context problems provide students with opportunities to develop informal solution strategies that are relevant for that specific context (Gravemeijer & Doorman, 1999). Students are not expected to reinvent everything themselves (Gravemeijer & Doorman, 1999). The teacher’s role is to facilitate learners through the process of guided reinvention, and provide students with the opportunity to reflect on the strategies they invented (Wisaja & Heck, 2003). It is important in teacher training, when learning about the reinvention process, that student teachers experience mathematization and reinvention first hand (Dolk et al., 2002). This can be extended to include activities such as anticipating learners’ solutions and analysing their work (Dolk et al., 2002).

Guided reinvention is also applicable in digital design. ICT provides opportunities for exploration and investigation which is well suited to reinvention (Drijvers et al., 2013); however in some cases, technology may constrain students’ opportunity for exploration as a result of pre-designed tools that provide too much guidance (Drijvers et al., 2013). There can also be tension between the reinvention process, which is considered to be bottom-up, and the nature of ICT, which tends to be top-down (Bakker et al., 2003).

3.3.4.2 Emergent Modelling

The term emergent modelling refers to the notion that models emerge from the activity of the students, and furthermore the required formal Mathematics emerges in the process (Gravemeijer, 1999; Gravemeijer & Doorman, 1999). The principle of emergent modelling focuses on the use of models during different phases of activities. A model is initially context-specific (Doorman et al., 2008; Doorman et al., 2013; Drijvers et al., 2013). This refers to a model which represents a meaningful, experientially real problem situation (Doorman et al., 2013; Drijvers et al., 2013; Kizito, 2012a). The
second phase continues as the learner works with the model where it gradually acquires a more generic character and progresses into a model for mathematical reasoning. This is possible because the model starts to refer to new mathematical objects in a more abstract framework of mathematical relations (Drijvers et al., 2013).

In the instructional design theory for RME, models are used to promote a process in which formal Mathematics is reinvented by the students themselves (Gravemeijer, 1999). It can be challenging for the designer of the tasks to find appropriate problem situations that are suited to the development of such models (Bakker et al., 2003; Drijvers et al., 2013; Gravemeijer, 1999). Instructional activities should be designed in such a way that students are able to shift from reasoning with models of informal activities to actual modelling of formal mathematical objects, relations and activities (Bakker et al., 2003; Doorman et al., 2013; Gravemeijer, 1999; Heck et al., 2007; Stephan & Akyuz, 2014). Thereby the formal Mathematics is made more accessible for the students (Gravemeijer, 1999). The task designer should support students in this transition from informal to formal by using tools that students have created, to explain their mathematical reasoning (Stephan & Akyuz, 2014).

Modelling and symbolising is an integral part of activities that aim to deal with problem situations (Gravemeijer & Doorman, 1999). The development of the model and the symbolization thereof complement the development of mathematical conceptualization of the problem situation (Gravemeijer & Doorman, 1999). Models are not derived from the intended Mathematics, but rather are grounded in the contextual problems that the students need to solve (Gravemeijer, 1999). The principle that underpins this notion is that students who work with the models will be motivated to reinvent the formal Mathematics (Gravemeijer, 1999). The purpose of using models is to bridge the phenomenological appearances of Mathematics in reality with formal Mathematics (Gravemeijer, 1999).

When analysing the design principle of emergent modelling, Gravemeijer (1999) refers to three interrelated processes. Firstly the process of the overall transition whereby the model emerges from informal mathematical activity, but gradually progresses into a model for more formal mathematical reasoning. The second process comprises the establishment of a new mathematical reality. Finally, the third process involves the emergence of a sequence of signification which serves as a concrete demonstration of the model in a sequence of signs, where each new sign can signify an activity with a previous sign (Gravemeijer, 1999). Emergent modelling can be a useful principle in digital design (Drijvers et al., 2013). When dealing with paper and pencil design, the models need to be suitable for further development in moving towards complexity and mathematical abstraction. In digital design, the emerging models must be supported by the digital tools that are available (Drijvers et al., 2013).
3.3.4.3 Didactical Phenomenology

The principle of didactic phenomenology is concerned with the relation between the thought object and the phenomenon itself (Drijvers et al., 2013). It deals with the concept of how mathematical structures can assist in organising and structuring phenomena in real life (Bakker et al., 2003; Drijvers et al., 2013; Zulkardi, 2000). Students are invited to develop mathematical concepts in this process (Bakker et al., 2003). The designer of the tasks is required to find meaningful phenomena that need to be structured and organised by the Mathematics (Drijvers et al., 2013).

The three RME principles can be well-utilised in digital design, although some adjustments may be necessary as compared to paper and pencil design (Drijvers et al., 2013). These principles however, are essential for digital design, despite the constraints of the digital tool (Drijvers et al., 2013). When dealing with digital design, the principle of didactical phenomenology is also valuable, however the phenomena that are dominant in the tasks do not necessarily come from real life (Drijvers et al., 2013). The student must contend with not only the world of Mathematics, but also ICT as a separate entity. Drijvers et al. (2013) are of the opinion that making use of a real life context together with these two domains can cause a cognitive overload.

3.3.5 Advantages, Disadvantages and Recommendations for Realistic Mathematics Education

3.3.5.1 Advantages

RME-based courses can help to improve learners' motivation, their understanding of Mathematics (Cahyono, 2012; Fauzan et al., 2013), their attitude towards Mathematics, their reasoning, activity and creativity and can assist in improving the classroom climate (Fauzan et al., 2013). RME is able to promote interactivity and collaboration in the classroom (Widjaja & Heck, 2003).

By following the RME approach, learners are able to make noteworthy progress in their performance in Mathematics, and both teachers' and learners' opinions about the teaching and learning activities are inclined to be positive (Widjaja & Heck, 2003). Learners tend to be more involved in the lessons and are more willing to try new and different things in classwork, and are less easily bored (Widjaja & Heck, 2003). Where technology is involved, learners become accustomed to new technologies (Widjaja & Heck, 2003). RME allows learners the opportunity to be actively involved in the learning process and promotes learning experiences that start with rich contexts (Fitzallen & Watson, 2014). Different classroom arrangements promote social interaction, stimulate the use of tools and improve reflection and generalisation (Doorman et al., 2013).

RME can be considered to be versatile, since an RME course designed for primary school Mathematics, which uses context problems and modelling, has proved to be suitable for an advanced
topic such as Calculus (Gravemeijer & Doorman, 1999). The use of the RME approach to teaching Mathematics allows for students to actively participate in the learning process. It sanctions the development of learning experiences that start with a rich and meaningful context that illustrates Mathematics in real life (Fitzallen & Watson, 2014).

3.3.5.2 Disadvantages

By following the RME approach, the classroom can become noisy and messy, but the positive effect of the approach outweighs this (Widjaja & Heck, 2003). Fauzan et al. (2013) report on some issues that emerged in classroom experiments when developing an RME-based course. They report that learners could not finish the contextual problems for reasons such as a negative attitude, dependence on the teacher, and they were not used to group work. They also report that with certain context problems, learners do not use the context to solve the problem because the statement did not guide them to do so (Fauzan et al., 2013).

3.3.5.3 Recommendations for Realistic Mathematics Education Based Lessons

The research of Widjaja and Heck (2003) has revealed recommendations for teachers who might want to introduce RME-based lessons that are supported by technology. Firstly, teachers should be willing to adapt their role in the classroom to more learner-centred and should refine their skills with regard to classroom discussions and dealing with challenging questions. Secondly, activities and tasks need to be carefully selected—there should not be too few activities, and also not too many, since either way, this could hamper the process of learning. They also point out that the logistical matters need to be attended to in advance for example preparing laboratories and making arrangement for group work (Widjaja & Heck, 2003).

3.4 Information and Communication Technology

Figure 3.5 illustrates ICT as one of the major themes that emerged from the systematic literature review.
3.4.1 The Value of Using Information and Communication Technology

There are numerous advantages discussed in the literature that highlight the value of using ICT in education. The use of ICT can promote student learning (Andresen, 2007) and promote mathematical reasoning (Widjaja & Heck, 2003; Zaranis, 2013, 2014b). Student learning can improve because educational technologies have various options to display data with different representations such as tables, graphs and formulas, which is particularly helpful when dealing with statistical concepts (Doorman et al., 2013; Fitzallen & Watson, 2014; Perez, 2012) and also to overcome the difficulty of integrating the operational and structural aspects of the function concept (Doorman et al., 2013).

The role of the teacher is described as both critical and problematic when it comes to integrating technology in teaching (Drijvers et al., 2010a). It is critical because the way in which teachers approach the use of technology has far-reaching consequences on the effects thereof in the classroom, and problematic because teachers find it difficult to adapt their teaching techniques when technology is incorporated, and can even avoid using technology when they do not perceive it to be useful (Drijvers et al., 2010a).

ICT has an imperative role to play in gathering information, acquiring data, processing and analysing data, solving problems, reporting and communication (Heck, 2009). It provides affordances for simulations, manipulation of data and is able to convert representations (Perez, 2012). Where possible, existing technologies should be extended and converted into concepts that work for school Mathematics (Heck et al., 2007) because technological developments encourage innovation in the teaching and learning of Mathematics by adjusting to conditions (Cahyono, 2012).

Not only have various research projects confirmed that the implementation of ICT in education can have positive effects on numerous subjects, but ideally, information technologies should be treated as
tools for teaching and learning (Zaranis, 2014b). ICT is a good facilitator to realise alternative approaches such as an activity-based approach or a realistic approach to Mathematics and Science instruction (Widjaja & Heck, 2003). Teaching and learning through ICT has a positive effect on the teaching of rectangles, circles, triangles and squares, particularly when using the RME approach (Zaranis, 2013, 2014c).

Computer tools provide opportunities for thinking and learning as they facilitate the learning activities that students engage with (Doorman et al., 2013). Computer aided learning is often a more enjoyable way of practising subjects that are otherwise seen as boring (Heck et al., 2008) and have shown to have a positive effect on the teaching of geometric shapes (Zaranis, 2014b). Educational software is found to be valuable in education, specifically Mathematics (Zaranis, 2013). Computer-assisted learning can significantly help in developing mathematical skills, and can promote deeper conceptual thinking than the traditional Mathematics teaching approach (Zaranis, 2014b, 2014c). When ICTs are treated as tools for teaching and learning, students can use these tools to become more familiar with new technology and can integrate investigation, communication and understanding across the curriculum (Zaranis, 2014c).

Technology also proves to be valuable for teachers (Dolk et al., 2002; Zulkardi, 2000). They can use web technology to store information like lessons or problems, can access information from anywhere in the world and discuss and share experiences after using the material in the classroom with colleagues or experts (Zulkardi, 2000). When using ICT in education, teachers that have less experience can be supported by experienced teachers, where shared experiences can be used to improve practice (Heck et al., 2007).

Learners’ appropriate use of computers can be related to their ability to more efficiently understand the different mathematical concepts as well as develop mathematical thinking in school (Zaranis, 2014b). Heck et al. (2007) have found that learners who practice Mathematics using mathematical tools on computers are better prepared for writing exams than for doing written assignments. Technology provides social interaction and additional opportunities for a rich learning environment (Zaranis, 2014b), and has a positive effect on children’s cognitive and sensory development (Zaranis, 2014c). The use of ICT can enhance students’ comprehensiveness in learning Mathematics and engage students in the learning process (Domazet et al., 2013). According to Kizito (2012a), the partnership that needs to exist between a student and teacher in a distance learning environment cannot take place without some form of technological intervention or mediation.

The Internet can provide students with access to the same resources that professionals make use of. It allows for students to gather information and make contact with experts in their field of study. It also enables students to not only gather subject information, but also to collect good quality real-time data, do computations that are otherwise impossible, build models using dynamic software and report results (Heck, 2009).
With the aid of technology, a learning environment can be designed in which students investigate and acquire practical knowledge which can be generalised to the broader teaching context (Dolk et al., 2002). An integrated learning environment can provide students with the following benefits: students can practice Mathematics anywhere and anytime; assignments can be generated randomly which means that exercise material can almost be considered to be unlimited; student work (activities and assessment) can be stored for future reference; and quality feedback can be given to students automatically (Heck et al., 2007; Risnawati et al., 2014). Direct feedback that gives students hints and suggestions, and allows for a trial and error approach, makes it possible for students to explore different strategies for solving problems (Heck et al., 2007).

Learners who work in a computer-learning environment are more actively involved in discussions and debates relating to their experimental work. They tend to talk more actively and are more aware of their own mathematical thinking (Widjaja & Heck, 2003). Virtual learning environments are able to integrate a variety of tools that function in the following ways: provision of information, communication tool, means for collaboration, learning and management (Cahyono, 2012). Discussion in a technological environment can be a great advantage because as the discussions reveal issues, different representations and techniques can be tested with fast and dynamic feedback (Drijvers et al., 2010a).

Digital activities can contribute in the field of education in that they allow children to participate in a world in which they learn to speak, think and act in new and different ways (Zaranis et al., 2013). These activities can benefit learners in the following fields: learning (well-designed activities provide motivation and encourage learning), cognitive skills (through repetition, spatial ability, visual attention) and social interaction (cooperative interaction) (Zaranis et al., 2013). Digital media can introduce learners to abstract concepts that were previously considered too advanced for their age, and encourage learners to work together (Zaranis et al., 2013). Digital assessment adds to the motivation and performance of learners in Mathematics education (Heck et al., 2007).

When learning activities are designed using ICT, it is important that they are done in such a way that learners actively engage with the Mathematics (Andresen, 2007). Digital technology should be embedded in an educational context in such a way that the technology is integrated in a natural way (Drijvers, 2013). It is therefore not only important that teachers need to be knowledgeable about Mathematics, but they also need to be prepared in basic technological literacy (Widjaja & Heck, 2003).

For teachers to benefit from using technology in everyday Mathematics teaching, it is important that they are adequately equipped with not only basic knowledge, but knowledge about new teaching techniques that are necessary in a technology-rich classroom (Drijvers et al., 2010a). The teachers’ knowledge of Mathematics as well as their beliefs and views about Mathematics education and the
role of technology in that, is an important aspect to consider when introducing technology into the classroom (Drijvers et al., 2010a). This will include aspects such as the teachers’ knowledge and skills on how to incorporate technology in the classroom and their concerns about time constraints and behavioural control (Drijvers et al., 2010a).

3.4.2 Information and Communication Technology Tools

Information technology offers invaluable possibilities for creating educational tools that can help students come to grips with various ideas (Gravemeijer, 2012). Different technology tools make it possible for teachers to track students’ progress and diagnose problem areas (Heck et al., 2007), and create new possibilities for problem solving in Mathematics by opening new horizons that lend themselves for exploration and problem solving activities (Doorman et al., 2007). By providing direct feedback and giving students hints and tips, teachers create a trial and error approach which makes it more possible for students to explore different strategies in order to solve the problem (Heck et al., 2008). Technology tools also influence the process of students’ sense making in Mathematics (Doorman et al., 2008), allow for students to review their mistakes and can store feedback which enhances the already positive effects of direct, instantaneous feedback (Heck et al., 2007).

Heck et al. (2007) distinguish between two types of applets, namely model applets, which aid in developing the mathematical understanding of concepts, and exercise applets, which can support the development of mathematical skills. Applets offer many benefits for learners: they are fun and motivate learners; they allow students to work at their own level, therefore addressing individual differences between learners; applets help to make the Mathematics easier to understand because of the visual, interactive and dynamic features they have; and their ability to do complex calculations allows learners to focus on the mathematical concepts and models. Students are more creative when using applets, have a more positive self-esteem and the practice and feedback features provide more benefits than pencil-and-paper exercises (Heck et al., 2007). Exercises on the applets help learners develop mathematical understanding and skills more thoroughly than with pencil and paper (Heck et al., 2008).

An important aspect to remember is that applets should be integrated in the daily classroom routine to gain their full benefits (Heck et al., 2007). Applets are able to provide feedback in cases of error as well as success. The feedback is both visual and audible, which makes it easy for learners to understand (Zaranis et al., 2013). For teachers, the benefits of using applets include being able to review what students actually did after a computer aided lesson: what progress they made, which problems arose and what areas need attention in future lessons (Heck et al., 2008).

GeoGebra is an open-source dynamic software for Mathematics that combines arithmetic, geometry, algebra, statistics and calculus (Stols, 2012). GeoGebra can be useful to provide competence development for teachers in terms of mathematical representations (Perez, 2012). Technology can
help create an active learning environment where students scan discover, explore and visualise (Stols, 2012). According to Stols (2012), in a study that investigated the geometric cognitive growth of pre-service Mathematics teachers in terms of the Van Hiele levels, it was found that dynamic geometry software could enhance students teachers’ geometric visualisation, analysis and deduction, but did not extend to the next Van Hiele levels of reasoning, informal justification and formal deduction.

When students are exposed to new technology, their skills and abilities are expanded in the computer-learning environment and they have the opportunity to improve their presentation skills (Widjaja & Heck, 2003). Interactive computer tools are able to present symbolic information such as graphs, models or numerical measures, which allow these tools to be employed successfully in enhancing the meanings of the symbolic information by making them more visible, accessible and more easily manipulated (Gravemeijer, 2012). A technology-enriched environment can improve the conceptual geometric growth of learners (Stols, 2012).

### 3.4.3 Devices

mLearning is defined as learning that takes place in learning environments and areas which make use of the mobility of technology, learners and learning (Zaranis et al., 2013). The term mobile learning (mLearning) is used in different contexts and involves a number of mobile devices such as mobile phones, personal digital assistants, handheld devices and notebooks (Kizito, 2012a). mLearning is an emerging and rapidly expanding field that provides new opportunities for education (Kizito, 2012a). In the past, mLearning was hampered by slow networks, limited services and hesitancy to invest in devices with a relatively short shelf life. Device attributes such as the screen size, battery life, security, and limited resources also delayed the adoption of mLearning (Kizito, 2012a); however mLearning is becoming a popular component of education. An added advantage of mLearning is in the distance education environment; where the majority of students cannot afford access to web-based learning, mLearning is a more viable alternative to provide instructional support (Kizito, 2012a).

Drijvers (2013) differentiates between three didactical functionalities for digital technology: the tool function for doing Mathematics; the function of providing the learning environment for practising skills; and the function of providing a learning environment for promoting the development of conceptual understanding. When designing digital technology, the guidelines and design heuristic should be guided by pedagogy and didactical considerations rather than the limitations or properties of technology (Drijvers, 2013). Digital activities are considered to be most effective when they are aimed at examining a specific problem or teaching a specific skill such as Mathematics, where detailed objectives can be determined (Zaranis et al., 2013). Digital educational activities are appealing to students’ interests as well as a pleasurable pastime and an attractive learning environment for them to work in (Zaranis et al., 2013).
Mobile devices offer many advantages in the learning process including stimulation, motivation, ease of use and availability. Mobile devices are becoming more valuable in education because they are attractive, portable, and more affordable in relation to desktop computers. They offer the opportunity for learning with wireless technology which allows for easy access to information, promotes digital literacy, and provides opportunities for independent learning (Zaranis et al., 2013).

Mobile devices fit better into the lifestyle of young children than desktop computers because they do not need to sit at a desk or in an office to use the device. The touchscreen is also irresistible for children (Zaranis et al., 2013). By introducing mobile technology in education, there is a positive correlation between the learners’ everyday life and their school life. Mobile devices can be used for various activities such as comparing, sorting, matching and counting (Zaranis et al., 2013). Educators should be sure to design the technological integration in such a way that learners are equipped with the necessary knowledge and skills they need in life (Zaranis et al., 2013).

The use of handheld technology in Mathematics education traditionally focused on content such as algebra and graphing, and took place in regular teaching sessions. It is now more common that these devices offer options for other topics such as geometry, and can be used outside the classroom due to the wireless options available (Wijers et al., 2010). The wireless option allows for opportunities for situated learning outside of school and encourages characteristics such as situated authentic learning, peer collaboration and motivational power (Wijers et al., 2010).

One of the many devices that can be used in the Mathematics classroom is the graphics calculator. The graphics calculator has the potential to stimulate learners to engage in informative exploratory activities, and can kindle the use of realistic contexts (Drijvers & Doorman, 1996). The realistic quality of a problem can be enhanced when using a graphics calculator, since the device takes care of the time-consuming technical work, allowing learners freedom to concentrate on the process of mathematization (Drijvers & Doorman, 1996).

Mobile phones have the potential to open opportunities for learners due to their mobility, accessibility and flexibility. They also enable students to engage in real, authentic tasks (Kizito, 2012a). Their benefits range from a means of communication and social networking to being handy as a learning medium (Risnawati et al., 2014). The mobile phone offers the feature of working collaboratively (sharing graphs and solving problems collectively), which assists in establishing a community of Mathematics learners (Kizito, 2012a). In South Africa, a mobile tutoring system known as Doctor Maths, is a very popular instant-messaging service that caters to over three million school-aged subscribers to support the teaching and learning of Mathematics (Kizito, 2012a).

The term smartphone describes mobile phones which have similar features and characteristics of tablets on a smaller screen, as well as the usefulness of voice data over cellular networks (Zaranis et al., 2013). Smartphones with multimedia facilities, which allow for data collection, the recording of
video images or audio clips and short message services, can potentially be useful for teaching and learning in many subjects. These features can assist students in building new knowledge (Kizito, 2012a). Smart mobile devices can be used to present digital activities such as exercises relating to comparing, sorting, matching, counting and the general knowledge of numbers (Zaranis et al., 2013).

An advantage of using tablets in education is that most tablets do not have phone features, which means there is less opportunity for disruption by incoming calls or text messages than with mobile phones. Tablets offer the benefit of mobile apps in a broader context, at all levels of education, and provide a rich tool which can be used inside and outside the classroom (Zaranis et al., 2013). Students can store educational materials in a digital portfolio (Zaranis et al., 2013). In a study that compared the outcomes that students were able to achieve through the traditional teaching approach as opposed to tablet aided learning, it was revealed that the tablet aided approach produced better learning outcomes for the students (Zaranis et al., 2013). The portability of tablets allows teachers and learners to use various locations in the classroom which allows for collaboration and creativity (Zaranis et al., 2013).

Various governments, worldwide, of both developing and developed countries, have in the last few years paid special attention to the development and implementation of mLearning in teaching and learning (Zaranis et al., 2013). However, affordability and ease of use of mobile devices are issues which can hinder effective delivery and acceptance by users (Kizito, 2012a).

Multimedia studies can act as a mediating tool in surpassing the contrast between theory and practice. It can also be instrumental in helping teachers develop situated practical knowledge about teaching (Dolk et al., 2002).

### 3.4.4 Information Communication Technology Systems: Virtual Learning Environment

A Virtual Learning Environment (VLE) is a collection of integrated tools that facilitates the management of online learning, provides a means of delivery, allows for student tracking, assessment, and provides access to resources (Heck et al., 2007). A VLE offers various functions, such as providing information, sanctioning communication, collaboration, learning and management (Heck et al., 2007).

An advantage of using an existing VLE that students and teachers are familiar with, is that users know how to log on to the system, how to send e-mails, how to work with the built-in communication tools, and how to export results to the administrative system (Heck et al., 2007). VLEs can promote anytime communication and interaction with the teacher and with fellow students which can take the form of text-based, audio or video communication. The VLE can also stimulate the students to do homework (Heck et al., 2007). Students tend to like the fact that teachers have insight into their work
through the VLE. Teachers are able to assist with common mistakes and therefore can address problems more effectively ( Heck et al., 2007).

Since virtual manipulations are similar to physical manipulations, using ICT could effectively support the learning process especially in Mathematics ( Zaranis et al., 2013). Virtual worlds provide a promising structure for learners since they are allowed to play many different roles ( Zaranis et al., 2013).

### 3.4.5 Information Communication Technology and Realistic Mathematics Education

Although there are challenges in the integration of ICT with the principles of RME ( Drijvers et al., 2013), various studies have shown that technology can act as a catalyst in the RME approach to teaching Mathematics ( Widjaja & Heck, 2003). Teaching by the principles of RME with the aid of educational software for tablets produces better outcomes than traditional teaching ( Zaranis et al., 2013). Instruction involving technology should equip learners with the necessary skills and knowledge for later life ( Zaranis et al., 2013).

When dealing with RME theory, where real world situations form the foundation of mathematical activities, software should be carefully chosen in order to stimulate these situations, recall old experiences and extend these to new ones by introducing purposeful interactions ( Boon, 2006). The mobile phone is useful in quickly determining a student’s starting point before designing instruction in the RME perspective ( Kizito, 2012a). An important aspect when using the RME approach in designing applets is that the problems that are presented should be real and meaningful to the learners and worth solving ( Heck et al., 2008).

### 3.4.6 Challenges when Working with Information Communication Technology

Teachers and learners alike can benefit from ICT in the form of different computer programs, lesson material and communication available on the Internet, and much more. However, not all stakeholders share the optimism about the effective use of ICT in teaching and learning ( Drijvers et al., 2010a; Heck et al., 2007).

The use of technology in Mathematics education should not be seen as an instant remedy that reduces the importance of the teacher ( Drijvers, 2013). When computers and technological tools are used continuously in the classroom, students can develop a dependency on these tools ( Zaranis, 2014b). An added challenge for teachers is that students can be at different levels of computer literacy, which the teacher will have to deal with in order to progress ( Zaranis, 2014b), and where online activities are prescribed for homework, a teacher needs to keep in mind that not all students have an Internet connection ( Risnawati et al., 2014). The use of technology challenges the stability of teaching practices, and the way teachers coordinate student learning ( Drijvers et al., 2010a).
Techniques that have always been used are often not suitable when technology is available. Teachers need to develop new teaching techniques that are applicable with the available tools (Drijvers et al., 2010a).

With regard to mobile technology, although there have been studies about the use of mobile phones in Mathematics education, Kizito (2012a) suggests that interviews should be used in future studies to explore the in-depth perceptions of students’ experiences of mobile phone technology. One of the limitations of the mobile phone in teaching Mathematics is the difficulty in manipulating symbols and equations; most mobile phones and smart phones have limited features to deal with this effectively (Kizito, 2012a). With the rapid advancement of technology, it might be possible in the near future to have affordable systems which allow easy manipulation of symbols (Kizito, 2012a). Kizito (2012a) is of the opinion that more focused research is required to investigate the use of the mobile phone in distance education.

3.5 Methodology: Design-based Research

Design-based research is cyclical in nature where thought experiments and teaching experiments alternate, following the process of analysis, design, development, implementation, evaluation and reflection (Bakker et al., 2003; Dolk et al., 2002; Doorman et al., 2013; Fauzan et al., 2013). Bakker et al. (2003) distinguish between micro cycles (at the level of the lessons) and macro cycles (at the global level of the teaching experiment). Design-based research is a means for the researcher to understand teaching, learning and educational systems (Bakker et al., 2003). Design-based research comprises articulating, testing and refining conjectures, designing instructional activities, and teaching experiments (Doorman et al., 2008).

Design-based research consists of three phases, namely the preliminary design phase, the teaching experiment phase, and the phase of retrospective analysis (Bakker et al., 2003; Perez, 2012). In the preliminary design phase, an HLT is developed and instructional activities are designed, and usually adapted as a result of the teaching experiment (Bakker et al., 2003). Fauzan et al. (2013, p. 166) use the following terms to refer to the three main phases of design-based research, namely: front-end analysis, the prototype phase, and the assessment phase. The purpose of front-end analysis is to get “a picture of the starting point and the potential end points of the course”. This normally involves needs analysis, literature reviews and the analysis of examples that are available (Fauzan et al., 2013). In the second phase, the instructional activities as well as the prior expectations rooted in the HLT are confronted with the reality of the classroom (Bakker et al., 2003). The third phase of design-based research involves data analysis and reflecting on the findings (Bakker et al., 2003).

Design based research has the following two purposes: to develop a prototypical product, with evidence of its quality, and to produce guidelines to design and evaluate that product (Fauzan et al.,
The development methodology needs to be systematically reflected on in order to produce design principles (Fauzan et al., 2013). Fauzan et al. (2013) summarise two different types of design-based research as presented by various other authors, namely validation studies and development studies. Validation studies focus on the design of learning environments to validate theories about the learning process; they aim to promote learning and instruction theories like RME. Development studies focus on design principles for developing innovative interventions that are significant for educational practice, which is done through a process of systematic reflection on the development methodology (Fauzan et al., 2013). It can happen that a study can be both a validation study and a developmental study (Fauzan et al., 2013).

Some reasons offered as to why design-based research is used include the following: design-based research affords a perspective to develop theory, the results are useful in the sense that educators can use the relevant research products and it gives researchers the opportunity to improve education by creating innovative designs (Dolk et al., 2002). Design based research within RME would reflect the three key principles of RME, namely guided reinvention, didactical phenomenology and emergent modelling (Fauzan et al., 2013). A detailed description of the methodology of design-based research was done in Chapter Two.

### 3.6 Role players

Traditionally, the role of learners was to listen, write and perform tasks provided by the teacher (Widjaja & Heck, 2003); however understanding is stimulated when learners are given an opportunity to be active, investigative learners, where they solve problems using their own strategies, as is required in RME (Dolk et al., 2002; Widjaja & Heck, 2003). In RME, learners need to be given space for exploration and constructing their own products and strategies (Dolk et al., 2002; Widjaja & Heck, 2003; Wijers et al., 2010).

The role of the teacher is also important in implementing RME principles (Doorman et al., 2008; Drijvers, 2013): he or she needs to guide discussions (Doorman et al., 2008; Gravemeijer, 2012), facilitate learners’ learning, and address challenging questions from learners; encourage them to think critically (Widjaja & Heck, 2003); allow learners space to do construction; ensure that open exploratory activities are used; give learners the opportunity to share and discuss their work, and contemplate relationships between different approaches (Dolk et al., 2002). For teachers to profit from technology in the Mathematics classroom, they need to have knowledge about emerging teaching techniques in technology-rich classrooms (Drijvers et al., 2010a).

Widjaja and Heck (2003) and Zulkardi (2000) testify to the changing role of learners and teachers in RME towards more learner-centred learning. Interactivity in the classroom increases and learners become more responsible for their own learning. This changing role requires the support of school
management to achieve success (Widjaja & Heck, 2003). In-service courses for teacher education should address teachers’ concerns and improve their knowledge and experience (Dolk et al., 2002). Teacher training, both in-service and pre-service, is essential since teachers are key figures in educational change (Zulkardi, 2000).

3.7 Chapter Summary

The chapter presented the review of the current literature with regard to the implementation of RME principles, aided by the use of ICT in Mathematics education. The themes of Mathematics, RME, ICT, methodology and role players were discussed. Table 3.1 lists the role of ICT in the RME approach to enhance teaching and learning.
Table 3.1  The role of Information and Communication Technology in the Realistic Mathematics Education Approach to Enhance Teaching and Learning

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<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Mathematics</th>
<th>RME</th>
<th>ICT</th>
<th>Methodology</th>
<th>Role players</th>
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<tbody>
<tr>
<td>(Andresen, 2007)</td>
<td>Introduction of a new construct: The conceptual tool &quot;Flexibility.&quot;</td>
<td>Teaching experiments were used to investigate the use of laptops in teaching differential equations using modelling.</td>
<td>The aim was to develop theory within the framework based on RME and related ideas.</td>
<td>Laptops</td>
<td>Case study</td>
<td>Upper secondary school Mathematics</td>
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<tr>
<td>(Bakker et al., 2003)</td>
<td>Design research on how IT may support the development of symbols and meaning in Mathematics education</td>
<td>The study focuses on how the use of IT in Mathematics education can help students reinvent mathematical concepts and representations. Different Mathematics topics were focused on. The challenge for Mathematics teachers is to develop Mathematics education that is in line with the conceptions of symbolising and developing meaning</td>
<td>RME is used as a background for the project.</td>
<td>The project investigated the contribution of ICT tools for the guided reinvention of mathematical concepts. It investigated the influence of ICT use on the students’ process of symbolising. Different types of technological tools were used.</td>
<td>Design-based research</td>
<td>Early statistics education. Eighth grade class.</td>
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<tr>
<td>(Cahyono, 2012)</td>
<td>Virtualmatriks: A Conceptual Mathematization Process in Virtual Learning Environment.</td>
<td>In the Virtual Learning Environment, students interact with the teacher and fellow students. This interaction can enhance the learning of mathematical concepts and their application in real life. The model positively impacts on student learning.</td>
<td>The study aims to develop a model relating to a Virtual Learning Environment based on RME</td>
<td>Virtual Learning Environment</td>
<td>The research is conducted in stages. Interventions are designed and validated</td>
<td>Senior high school</td>
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<tr>
<td>(Dolk et al., 2002)</td>
<td>Using multimedia cases for</td>
<td>This project is to understand how</td>
<td>The project is based on the RME approach.</td>
<td>No ICT</td>
<td>The cyclical nature of the design-based</td>
<td>Pre-service Mathematics education</td>
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<tr>
<th>Author(s)</th>
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<tr>
<td>Domazet &amp; al., 2013</td>
<td>Mathematics Competence and International Mathematics Testing: Croatian Starting Point</td>
<td>The paper reviews the concept of compulsory Mathematics education and appropriate instruction methods. The paper reviews the concepts behind the social influences on the development of literacy in Mathematics education.</td>
<td>Links are made between the theoretical framework of PISA and RME. Mathematics education is no longer just about transferring mathematical knowledge, but about satisfying broader social goals in that.</td>
<td>No ICT</td>
<td>The paper maps past and current, and possible future, changes in the conceptualisation of school Mathematics and Mathematics teaching in Croatian compulsory education.</td>
<td>Croatian primary schools</td>
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<tr>
<td>Doorman &amp; al., 2013</td>
<td>Design research in Mathematics education: the case of an ICT-rich learning arrangement for the concept of function</td>
<td>The concept of functions is an important but difficult topic in secondary school Mathematics curricula. It can be challenging for learners since the concept develops from calculation operations to objects. Various lessons promoted the conceptual understanding.</td>
<td>The theoretical framework for this study is made up of three components: the knowledge of the function concept, emergent modelling (which is a principle of RME) and theories on tool use.</td>
<td>The study dealt with the design and evaluation of an ICT-rich learning environment for Grade eight learners. The computer tool that was used is an applet called AlgebraArrows. This permits the construction and use of chains of operations and provides opportunities for tool use.</td>
<td>The methodology for the project was design-based research. It was carried out in a cyclic process of three design cycles, one pilot and two full cycles, each lasting for about one year.</td>
<td>Grade 8 learners (age group 13-14 year) in the Netherlands</td>
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<td>(Doorman et al., 2008)</td>
<td>Tool use and the development of the function concept: from repeated calculations to functional thinking</td>
<td>development of functions. The final test data did not reveal whether all students improved with regard to the understanding of functions.</td>
<td>creating tables, graphs and formulae. The applet is used to provide tasks which the teacher can monitor.</td>
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<td>An initial small-scale pilot study took place. Thereafter the learning arrangement was tested and improved in two successive teaching experiments in Grade 8, with mid- and high-achieving 13–14-year-old learners.</td>
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<td>(Doorman et al., 2007)</td>
<td>Problem solving as a challenge for Mathematics education in The Netherlands</td>
<td>The study focuses on activities with computer tools that help students to construct mathematical representations and actions. They are given the opportunity to explore the representations. The concept of functions is explored. The transition from function machines to actual objects is represented in different ways.</td>
<td>One aspect that forms part of the theoretical framework is emergent modelling, which has its foundation in the theory of RME.</td>
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<td>A total of 152 high-achieving fourth grade learners (9 – 10 year olds).</td>
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<td>(Doorman et al., 2008)</td>
<td>Tool use supporting the learning and teaching of the Function concept</td>
<td>Tool use and the development of the function concept: from repeated calculations to functional thinking</td>
<td>The study reports on a project where the following activities are combined: paper and pencil and computer tools as well as the careful guidance of the teacher. The tool that is used is an applet called AlgebraArrows. This which permits the construction and use of chains of operations and provides options for creating tables, graphs, and formulae.</td>
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- **Tool use and the development of the function concept: from repeated calculations to functional thinking**
  - The study focuses on activities with computer tools that help students to construct mathematical representations and actions. They are given the opportunity to explore the representations. The concept of functions is explored. The transition from function machines to actual objects is represented in different ways.

- **Problem solving as a challenge for Mathematics education in The Netherlands**
  - The focus was on the implementation of a problem based curriculum, centred on the principles of RME and incorporated the use of technology.

- **Tool use supporting the learning and teaching of the Function concept**
  - The focus is on the use of computer tools for grade 8 (13-14 years) students’ acquisition of the concept of functions. The aim is to identify the relationship between the use of technological tools and

- **No ICT**

- **Computer tools**

- **The research process involves a cyclical process of instructional design, teaching experiments and data analysis.**

- **Grade 8 learners**
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<tr>
<td>(Drijvers, 2013)</td>
<td>Digital technology in mathematics education: Why it works (or doesn't)</td>
<td>The study shows that the success or failure of the integration of technology in Mathematics education relies on three factors: the design, the role of the teacher, and the educational context. The study identified factors that promote or hinder the successful integration of digital technology in Mathematics education.</td>
<td>RME is one of the theoretical perspectives that is investigated in this study.</td>
<td>The paper looks at the contribution of technology in Mathematics education from a more realistic perspective.</td>
<td>Six different cases from leading studies in the field were studied.</td>
<td>The role of the teacher is extremely important in the incorporation of technology in Mathematics education.</td>
</tr>
<tr>
<td>(Drijvers et al., 2013)</td>
<td>Digital design: RME principles for designing online tasks</td>
<td>The design of tasks is important—this paper explores how the RME principles which are usually used for paper-and-pencil tasks can be used in a digital environment. Examples of tasks relating to Algebra, Calculus and Geometry are designed and presented in the Digital Mathematics Environment.</td>
<td>The paper investigates how the principles of RME can be used to design online tasks. They concluded that the principles of guided reinvention, didactical phenomenology, and emergent modelling can inform and guide digital design.</td>
<td>A Digital Mathematics Environment (DME) is used. The DME integrates a content management system, a learning management system and an authoring environment.</td>
<td>This is a theoretical paper in which different digital designs of tasks for Algebra, Calculus and Geometry are studied.</td>
<td>Grade 8 learners</td>
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<td>(Drijvers &amp; Doorman, 1996)</td>
<td>The graphics calculator in mathematics education</td>
<td>This study supports the notion that the graphics calculator can encourage the use of realistic contexts. The graphics calculator is used to integrate Algebra and Geometry and encourages the learner to create links</td>
<td>The theory of RME was used as point of departure for the study.</td>
<td>Graphics calculator</td>
<td>Developmental research.</td>
<td>Prevocational secondary education (16 year olds).</td>
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<td>(Fauzan et al., 2013)</td>
<td>The Development of an RME-based Geometry Course for Indonesian Primary Schools</td>
<td>between the different aspects of Mathematics</td>
<td>A Geometry course for Indonesian primary schools was based on the RME approach.</td>
<td>Design-based methodology was followed. The three stages, namely front-end analysis, the prototyping stage, and the assessment stage were conducted over a four year period.</td>
<td>Grade 4's at an Indonesian primary school</td>
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<td>(Fitzallen &amp; Watson, 2014)</td>
<td>Developing a Sequence of Learning Experiences in Statistics</td>
<td>The study involved the use of an RME-based geometry course for teaching geometry at grade four in Indonesian primary school. The aim was to improve pupils' understanding, reasoning, activity, creativity, and motivation.</td>
<td>RME is used as a guide for student learning that focuses on the development of abstract thinking.</td>
<td>The learning experiences are facilitated by the software package TinkerPlots: Dynamic Data Exploration.</td>
<td>Sequences of learning experiments are given to learners.</td>
<td>Secondary school</td>
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<td>(Gordon et al., 2012)</td>
<td>Keyconet 2012 Literature Review: Key competence development in school education in Europe</td>
<td>Based on the principles of RME</td>
<td>No ICT</td>
<td>Literature review</td>
<td>Learners in general</td>
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<td>(Gravemeijer, 2012)</td>
<td>Aiming for 21st</td>
<td>The article argues that</td>
<td>A reform approach to</td>
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<td>Literature review</td>
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<td>2012)</td>
<td>century skills</td>
<td>interactive, problem-centred Mathematics education will contribute to most 21st century skills.</td>
<td>Mathematics education is followed, where students have to reinvent Mathematics by themselves with the help of the teacher and the textbook. This links with the tradition of RME.</td>
<td>mathematical skills that are needed in a computerized environment. The article analyses the role computers and computerized appliances play as interfaces between the users and reality.</td>
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<tr>
<td>(Gravemeijer &amp; Doorman, 1999)</td>
<td>Context problems in realistic mathematics education: A calculus course as an example</td>
<td>In RME, context problems are intended to sustain a reinvention process that enables students to understand formal Mathematics. In this article, the authors argue that discrete functions and their graphs play an essential role as a midway between the context problems that have to be solved and the formal calculus that is developed.</td>
<td>The RME approach is used to design a Calculus course that relies on context problems.</td>
<td>No ICT</td>
<td>Theoretical article</td>
<td>Primary school Mathematics</td>
</tr>
<tr>
<td>(Gravemeijer, 1999)</td>
<td>How Emergent Models May Foster the Constitution of Formal Mathematics.</td>
<td>The article deals with the role that emergent models can play in establishing formal Mathematics. An instructional sequence is designed which deals with mental computation strategies for addition and subtraction up to 100. This elaborates on what is meant by emergent models and the role they play in</td>
<td>The study is based on instructional design theory for RME.</td>
<td>No ICT</td>
<td></td>
<td>Primary school</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Mathematics</td>
<td>RME</td>
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<tr>
<td>(Heck, 2009)</td>
<td>Modelling in cross-disciplinary authentic student research projects</td>
<td>developing formal Mathematics.</td>
<td>The RME principles of using relevant contexts and of considering Mathematics as a human activity are prevalent in this paper. This implies that students make sense by participating in the mathematical representation process.</td>
<td>The examples in this paper show that ICT can contribute to the recognition of true review. Students are given the opportunity to process, analyse and visualise data; to do calculations that are normally cumbersome; and to compare and report results from experiments, models, and theory.</td>
<td>Three examples of students’ inquiry work are analysed.</td>
<td>Dutch secondary school</td>
</tr>
<tr>
<td>(Heck et al., 2007)</td>
<td>Applets for learning school algebra and calculus</td>
<td>The article explores in what ways applets can help student to develop algebraic understanding and skills. In this project, they try to extend existing technologies into concepts that work for school Mathematics. They also produce learning materials that is based on technology.</td>
<td>The RME approach was the key theoretical framework for the design of the software and of the instructional material.</td>
<td>The focus is on the development and use of Java applets for learning and practising Algebra and Calculus at secondary school level.</td>
<td>Developmental work during the GALOIS project.</td>
<td>Secondary school calculus students</td>
</tr>
<tr>
<td>(Heck et al., 2008)</td>
<td>Mathematica empowered applets for learning school algebra and calculus</td>
<td>The article describes the development and use of applets that are empowered by Mathematica. These are used for learning and practising Algebra and Calculus at secondary school level. The applets help the teacher to understand the learning process of</td>
<td>The RME approach was the key theoretical framework for the design of the computer programs and the accompanying lesson material.</td>
<td>The applets provide scoring facilities, are integrated in a virtual learning environment Here answers are stored, and can be edited by teachers to create their new tests and exercises.</td>
<td>Developmental work</td>
<td>Secondary school level</td>
</tr>
<tr>
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<td>(Kizito, 2012a)</td>
<td>Pretesting mathematical concepts with the mobile phone: Implications for curriculum design</td>
<td>This paper describes the characteristics of a diagnostic test which was used to determine initial student understanding of the basic Calculus concepts of the derivative and the integral before the start of their course. The aim of the project was to try to find out what the didactic functionalities of a mobile phone were and how these could be used to support the learning of Mathematics through distance education.</td>
<td>RME was used as the theoretical framework for this project. This testing was part of a larger project that examined what was required to adapt the instructional design viewpoint of Realistic Mathematics Education (RME) to the teaching and learning of Calculus via distance education.</td>
<td>The mobile phone was used as mode of delivery for the diagnostic test. The speed and ease of following the students’ results was a positive aspect of the mobile phone, while issues of availability like cost and ease of use was an imitation.</td>
<td>Pilot study</td>
<td>The students were UNISA students who had completed their first semester in a first-year calculus course.</td>
</tr>
<tr>
<td>(Mousoulides et al., 2007)</td>
<td>From problem solving to modelling</td>
<td>In this paper, the concept of emergent modelling is explored from the field of problem solving. The importance of modelling is discussed from the existing literature.</td>
<td>The use of modelling problems can enhance student sense-making within a real context. It can bring real world situations into school Mathematics, which aids in fostering a positive attitude towards Mathematics.</td>
<td>No ICT</td>
<td>In essence, this study followed the structure of design-based research. The modelling approach involves a number of iterative cycles, in which students refine their results and improve their solutions.</td>
<td>The paper is a literature review that explores the emergence of modelling within the genre of problem solving research</td>
</tr>
<tr>
<td>(Perez, 2012)</td>
<td>Scaffolding Teachers’ Construction of a Learning Trajectory for Mathematics Supported by ICT</td>
<td>The teachers indicated content areas that their learners found challenging—the first theme that was identified was Algebra, in particular the</td>
<td>The instructional theory of RME is used to develop a hypothetical learning trajectory (HLT) to develop class activities that reflect the notion that</td>
<td>This project explores how technology can be used to improve teachers’ teaching practices and their students’ learning of Mathematics. In</td>
<td>This is a developmental project that makes use of a methodology of co-design, a user-centred, collaborative approach to design-based research. It is suitable</td>
<td>Two Mathematics teachers at a lower secondary school in Sweden</td>
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<td>Author(s)</td>
<td>Title</td>
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<td>(Risnawati et al., 2014)</td>
<td>The development of realistic mathematics education-based blog at linear algebra course in UIN Suska Riau</td>
<td>The blog is related to Algebra courses so that the students can access courses they need anywhere and at any time. Students can review the effectiveness of blogs in supporting the learning process of Algebra.</td>
<td>The development of the RME-based blog was effective as learning media and as a source to improve students' understanding of Algebra.</td>
<td>Technology tools such as laptops, smartphones and tablets as well as social networks such as Facebook, Twitter and others are commonly used by students for personal and social purposes. This project focuses on the academic use of technology.</td>
<td>Development research.</td>
<td>Students studying Linear Algebra at university.</td>
</tr>
<tr>
<td>(Stols, 2012)</td>
<td>Does the use of technology make a difference in the geometric cognitive growth of pre-service mathematics teachers?</td>
<td>The study investigated to what extent pre-service Mathematics teachers' cognitive growth in Geometry improved in terms of the Van Hiele levels. The study found that the use of dynamic geometry software enhanced student</td>
<td>The design of the geometry course was loosely based on the five tenets developed by the Realistic Mathematics Education (RME) movement.</td>
<td>This investigation took place in a technology-enriched environment and compared these students' growth with that of students in a learning environment without any technological enrichment.</td>
<td>A quasi-experimental non-equivalent comparison group design was used. A control and experimental group was used in the study.</td>
<td>Third year BEd pre-service Mathematics teachers.</td>
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<td>Author(s)</td>
<td>Title</td>
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<td>RME</td>
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<td>(van Loon-Hillen, van Gog, &amp; Brand-Gruwel, 2012)</td>
<td>Effects of worked examples in a primary school mathematics curriculum.</td>
<td>teachers’ geometric visualisation, analysis and deduction, but not their ability to informally justify their reasoning and to understand the formal aspects of deduction.</td>
<td>For a three week period, the study tested the effects of relying more heavily on worked examples, as analogies for problem solving. The curriculum was used to teach both the control group and the experimental group. Although the results showed no significant difference in performance or cognitive load; the experimental group achieved this level with significantly less acquisition time.</td>
<td>The existing curriculum was taught using a RME teaching approach.</td>
<td>The study made use of a quasi-experimental design.</td>
<td>Primary school Mathematics class, using the existing curriculum.</td>
</tr>
<tr>
<td>(Widjaja &amp; Heck, 2003)</td>
<td>How a realistic mathematics education approach and microcomputer-based laboratory worked in lessons on graphing at an Indonesian junior high school</td>
<td>The project investigated the expectations, performance, and opinions of the pupils and the teacher with respect to graphing activities using a computer tool. The content that was used in this project was graphs with emphasis on interpretation and application.</td>
<td>The RME approach was used. The results of the project indicated that the pupils made remarkable progress in their performances that can be attributed to the approach that was used.</td>
<td>The project made use of Microcomputer-Based Laboratory (MBL). Computer tools were used for measuring data in practical work.</td>
<td>The research experiment was set in a classroom situation where the pupils made use of the designed classroom activities. Pre- and post-tests were used to investigate the effect of the ICT-rich RME-based instructions on the pupils’ graphing skills.</td>
<td>One class with 13 – 14 year old pupils (Junior High School) used the materials and activities that were designed. This was done in an Indonesian classroom context.</td>
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<td>Author(s)</td>
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<tr>
<td>(Zaranis, 2013)</td>
<td>The use of Information and Communication Technologies in the first grade of primary school for teaching rectangles based in Realistic Mathematics Education</td>
<td>The purpose of the study was to investigate the impact of the intervention of Primary Shape Model (PSM) on the Geometry competence of the first grade learners, This model was based on the Van Hiele levels and also on the RME principles.</td>
<td>The educational software was designed following the principles of RME.</td>
<td>The first level of the Primary Shape Model (PSM) started with the educational software which was designed using Flash CS3 Professional Edition. Various computer activities were included in the following levels.</td>
<td>An experimental group, were taught rectangles with computers and a control group received only the traditional instruction relating to rectangles. Students in both groups were pre-tested and post-tested for their performance in Geometry.</td>
<td>First grade learners from ten primary schools in Athens and Crete.</td>
</tr>
<tr>
<td>(Zaranis, 2014c)</td>
<td>The use of ICT in the first grade of primary school for teaching circles, triangles, rectangles and squares</td>
<td>This study investigated whether ICT helps to improve first grade students’ basic Geometry achievement regarding circles, triangles, rectangles and squares or not. The study examined and compared the effects of a new model which made use of both computer and non-computer activities for teaching circles, triangles, rectangles and squares separately.</td>
<td>Rather than following a traditional teaching method, the RME approach was used to present the material.</td>
<td>A story called ‘The Family of Shapes’ was presented to the students. Various geometrical shapes were presented in a fictional family setting where each member of the family represented a particular shape. The story was designed using Flash CS3 Professional Edition and presented with a video projector in the classroom.</td>
<td>There was an experimental and control group. The experimental group were taught about circles, triangles, rectangles and squares with the support of computers. The students in the control group were not exposed to the computer oriented curriculum. Students in both groups were given pre-tests and post-tests to establish their Geometry performance.</td>
<td>First grade learners from ten public primary schools in Athens and Crete.</td>
</tr>
<tr>
<td>(Zaranis, 2014a)</td>
<td>Geometry Teaching Through ICT in Primary School</td>
<td>Using computer based mathematical teaching to teach learners can significantly help in developing proper mathematical skills and cultivate deeper conceptual thinking than in traditional teaching. The Van Hiele model formed</td>
<td>The software that was designed and the students’ activities that were developed for this study were inspired by the framework of RME.</td>
<td>Technology was used to create a rich learning environment, consistent with the modern era.</td>
<td>Experimental research</td>
<td>First grade pupils</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Mathematics</td>
<td>RME</td>
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<td>(Zaranis, 2014b)</td>
<td>The use of ICT in kindergarten for teaching addition based on realistic mathematics education</td>
<td>The study investigated the effect of ICT on learners’ achievement in addition and counting. The researcher and the teachers developed a model which combines the principles of RME and the use of ICT in kindergarten. The main purpose of the model was to foster learners’ mathematical concepts and skills about addition and to involve them in self-regulated learning. Some activities were computer activities and others not.</td>
<td>A comparison is made between learners who are taught by the traditional approach as opposed to those being taught by the principles of RME.</td>
<td>The learners were given software that consisted of a story and several activities, some with the use of computers and others without. The results showed that the use of computers had a positive effect on the learning of addition.</td>
<td>The learners were divided into two groups—the experimental group who were taught with computers and the control group who were not exposed to the computer oriented curriculum.</td>
<td>The participants were kindergarten learners in Crete.</td>
</tr>
<tr>
<td>(Zaranis et al., 2013)</td>
<td>Using mobile devices for teaching realistic mathematics in kindergarten education</td>
<td>The activities are based on the fundamental Mathematical concepts of kindergarten. These include counting and simple addition and subtraction. The paper investigated the use of ICT in preschool education, as well as the learners’ knowledge</td>
<td>The project revealed that the teaching of RME with the use of educational software for tablets produces better learning outcomes than traditional teaching methods.</td>
<td>The purpose of the paper was to provide a better understanding of the characteristics and the effect of ICT and mLearning in preschool education. The results showed that the use of the tablet supported learning compared to the traditional teaching method without technology.</td>
<td>An instructional intervention.</td>
<td>The initial pre-tests were done with a small sample of kindergarten learners in a specific region in Greece.</td>
</tr>
<tr>
<td>(Boon, 2006)</td>
<td>Designing didactical tools and microworlds for mathematics educations</td>
<td>This paper reflects on the role of (solving) algorithms in Mathematics education with the aid of</td>
<td>The theoretical foundation of this work is based on the theory of RME. The main purpose of this theory</td>
<td>The paper distinguishes between three types of applets: applets that offer a virtual reality, those that</td>
<td>The paper reports on the design activities in the field of small didactical fields and Java applets done at</td>
<td>Various studies were referred to in this paper.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Mathematics</td>
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<td>(Stephan &amp; Akyuz, 2014)</td>
<td>An Instructional Design Collaborative in One Middle School</td>
<td>The researchers designed and implemented a HLT and instructional tasks to teach Integers</td>
<td>All tasks that were designed used the design principles of RME, where the focus is on the development of a sequence of tasks, rather than stand-alone problems.</td>
<td>No ICT</td>
<td>The Freudenthal Institute over a number of years.</td>
<td>One middle school in Florida, USA (12 – 14 year olds)</td>
</tr>
<tr>
<td>(Cobb et al., 2008)</td>
<td>Learning from and Adapting the theory of realistic mathematics education</td>
<td>Experiments were designed relating to the teaching and learning of statistical data analysis</td>
<td>Adaptations were made that built on the RME approach to the design of learning material.</td>
<td>No ICT</td>
<td>Design-based research</td>
<td>A US Middle school in a seventh-grade classroom with 29 twelve-year-old students</td>
</tr>
<tr>
<td>(Drijvers et al., 2010a)</td>
<td>The teacher and the tool: instrumental orchestrations in the technology-rich mathematics classroom</td>
<td>The project consisted of eight 50-min lessons, aimed at the development of the function concept. Teachers’ choices regarding intervention were in line with their views on the teaching of Mathematics.</td>
<td>The design was guided by RME principles.</td>
<td>The technology used in this project was a Java applet called Algebra Arrows. The applet was embedded in an electronic learning environment called the Digital Mathematics Environment (DME). The applet allows for the construction and use of chains of operations and provides options for creating tables, graphs and formulae.</td>
<td>The intervention took place in three research cycles, each consisting of a (re)design phase, a teaching experiment phase and a data analysis phase.</td>
<td>Secondary education – eighth grade students</td>
</tr>
<tr>
<td>(Wijers et al., 2010)</td>
<td>Mobilemath: exploring mathematics outside the classroom</td>
<td>This project investigated the effect of a location-based game with hand held technology (HHT) on the engagement in mathematical activities.</td>
<td>The study’s theoretical framework is formed by notions on engagement, and on authentic RME.</td>
<td>HHT offer options for topics, such as Algebra, graphing and geometry, and can be used outside the classroom, because of wireless</td>
<td>Explorative design-based research was used. Data were gathered by means of participatory observation, online storage of game data,</td>
<td>The project was tested in a pilot on three different secondary schools with 60 12–14-year-old students.</td>
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<td>Author(s)</td>
<td>Title</td>
<td>Mathematics</td>
<td>RME</td>
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<td>(Zulkardi, 2000)</td>
<td>Realistic Mathematics Education theory meets web technology</td>
<td>The reform in Indonesian Mathematics is discussed under the following three sections: The new goal is described as Maths literacy, the new theory as RME and the new content is a meaningful context. The reform of Mathematics from traditional teaching to problem solving is discussed.</td>
<td>Based on RME principles. RME is seen as an innovation in Mathematics education.</td>
<td>Communication. These mobile devices can engage students in meaningful learning, inside as well as outside of school.</td>
<td>Theoretical paper</td>
<td>Various learners</td>
</tr>
<tr>
<td>(Freudenthal, 1968)</td>
<td>Why to Teach Mathematics So as to Be Useful</td>
<td>Mathematics as a human activity; real life and useful</td>
<td>Foundations for RME</td>
<td>none</td>
<td>Theoretical</td>
<td>Teachers, Learners</td>
</tr>
<tr>
<td>(Simon, 1995)</td>
<td>Reconstructing Mathematics pedagogy from a constructivist perspective</td>
<td>The data led to a model of how teachers make decisions with regard to tasks.</td>
<td>Discussion about HLT</td>
<td>none</td>
<td>The role of constructivist theory in Mathematics Education</td>
<td>Teachers and learners</td>
</tr>
<tr>
<td>(Treffers, 1993)</td>
<td>Wiskobas and Freudenthal Realistic Mathematics Education</td>
<td>Reality is the source of learning.</td>
<td>Discussion of Freudenthal’s foundations of RME</td>
<td>none</td>
<td>Theoretical</td>
<td>Teachers, learners</td>
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<td>Author(s)</td>
<td>Title</td>
<td>Mathematics</td>
<td>RME</td>
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<td>(Freudenthal, 1991)</td>
<td>Revisiting Mathematics Education: China Lectures</td>
<td>The essence of RME</td>
<td>Foundations of RME</td>
<td>none</td>
<td>Theoretical</td>
<td>Teachers, learners</td>
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Chapter Four

Participants' Needs and Perceptions with regard to Real Life Mathematics

4.1 Introduction

In this chapter I report on the data set that I obtained when doing the needs analysis individual interviews with the participants. Two factors were the driving force behind the necessity to do a needs analysis with the participants. Firstly, the systematic literature review exposed various aspects that should be further explored within the context of this study. Secondly, the needs analysis was driven by the research sub-question: What support needs do teachers have in order to successfully implement the RME approach in their teaching practice?

A closer analysis of the research sub-question revealed that there were various areas that had to be investigated in order to sufficiently answer the question that this study proposed. It was therefore necessary to meet with the participants in order to ascertain their perceptions and experiences relating to a number of aspects. These aspects include the following: which content areas they found problematic to teach; which content areas their learners found challenging; and the facets of the curriculum they had difficulty in relating to real life situations. I also obtained information about their perceptions and ideas about teaching Mathematics in a realistic way as well as their observations about the use of technology in Mathematics teaching and learning. These aspects would inform the design process of the mobile app (Chapter 5).

The way in which I obtained this information was by conducting individual interviews with four teacher-students. I designed an interview schedule (Addendum 2.6) based on the findings of the systematic literature review as well as the requirements needed to answer the research sub-question. I made use of purposive sampling to select the participants. These students all attended contact sessions at the Potchefstroom Campus of the NWU and agreed to meet with me and participate in this research. They also all complied with the criteria for selection, which were discussed in § 2.8.1. The individual meetings took place at a location and at a time convenient for the students and did not interfere with their teaching schedule in any way. Two meetings took place at my office at the Potchefstroom Campus of the NWU. The third meeting took place at one participant’s school in Potchefstroom in the HOD’s office and the fourth meeting took place at a coffee shop in Ventersdorp. I paid for the transport costs of the participants that needed to travel to Potchefstroom, and I provided all participants with refreshments to ensure that they were comfortable and not inconvenienced in any way.
I transcribed each interview and coded these interviews with the aid of ATLAS.ti™, a Computer Assisted Qualitative Data Analysis Software (CAQDAS) (ATLAS.ti, 2014). Data were coded in the same HU as the systematic literature review in ATLAS.ti™. I therefore used the existing codes and created additional codes where necessary in order to code and categorise the interviews as part of an integrated HU. The detailed codebook was discussed in Table 2.6 (§ 2.6.5). In order to ensure the trustworthiness of the coding, two peers who are experts in the fields of Mathematics education peer-coded one interview (§ 2.8.3.2) Cohen’s Kappa was calculated as 0.99 which therefore validated this process. This calculation can be seen at Addendum 2.7. The systematic literature review revealed five main themes; four of these five themes were used to structure the analysis of the interview data. The four main themes used in this chapter were: Mathematics, RME, ICT and role players. In order to analyse the interviews, these themes were further refined as: participants’ needs in term of Mathematics; the facets of RME that arose in the interviews; their thoughts and ideas about ICT; and finally the role players that played a part in the given context (Figure 4.1). Each of the said main themes has various sub-themes that will be further explored in this chapter.

![Figure 4.1: Advance Organiser of the Main Themes for the Analysis](image-url)
Figure 4.2 illustrates the network view of the coding structure and themes that arose from this set of data, the four main themes being: Mathematics; RME; ICT; and finally role players. As discussed above, when analysing the data, these themes were made more specific in order to zoom in on the interview data. Due to the fact that the participants were asked to share their perceptions and experiences of aspects relating to these themes, I focused the discussion on their perceptions of these critical themes. This chapter reveals those support needs as well as other insights that the student-teachers had in terms of realising the RME approach in their classrooms.

Figure 4.2: Coding Structure for the Needs Analysis Individual Interviews

4.2 Needs and Perceptions in Terms of Mathematics

The three sub-themes that emerged within this main theme are: factors that influence teaching and learning; Mathematics content—with the specific focus on areas that the participants found problematic to teach as well as content that can be related to real life; and learner aspects. Figure 4.3 indicates the participants’ needs with regard to the Mathematics that they are teaching.
4.2.1 Factors that Influence Teaching and Learning

One of the factors that clearly stood out in the interviews was the participants’ aspirations to move forward. Not only are they currently studying to improve their qualifications, although they are employed full-time, but they expressed their desire to develop in other ways as well which could improve teaching and learning:

*Then if they are not doing well, I used to think that maybe I need some sort of development (P59:23).*
*So, I'm learning again (P49:3).*
*If I’m given a chance everything is okay (P49:37).*
*Yes, I am eager I am eager you know (P60:72).*

Another aspect that influences the teaching and learning of Mathematics is establishing good foundations of Mathematics from the Foundation Phase already:

*I think it’s because they lack a proper foundation, the problem starts at the foundation phase (P59:7).*

Not only does what takes place in the classroom impact on students’ learning (Samuelsson, 2010, p. 61), but early Mathematics knowledge and skills are said to be the most important predictors for later achievement in Mathematics, and also for achievement in other content areas (Claessens & Engel, 2013, p. 1).

Immediate feedback to learners is an essential aspect of effective teaching and learning (Sancho-Vinuesa, Escudero-Viladoms, & Masla, 2013, p. 1). The participants also reported that immediate feedback to the learners was important:

*It will help the learners, even with speed. Uh, marking, even that immediate feedback, because if you are given feedback immediately, you can try it again (P59:67).*
4.2.2 Mathematical Content

In this section, the data revealed two sub-themes relating to Mathematics content, namely: problem areas to teach and learn, and content related to real life. The first sub-theme revealed the following information about areas the learners found challenging and also facets of the curriculum that teachers found to be problematic. The areas of the curriculum that were most problematic for the participants to teach were: Financial Mathematics; Geometry; Probability; Algebra; Integers; Counting techniques; Graphs; Functions; the application of Calculus and Trigonometry. In some cases the content was problematic for the learners as well:

Learners do have a problem with algebra and integers in fact. If they do have a problem with integers, it is going to give them a problem when dealing with algebra (P59:4).

In some cases the teachers found the content challenging as well:

Then, recently we have Euclidean geometry which has been introduced. Uhm, it’s also a major problem, but I think the problem is not the learners but maybe the majority of teachers who are teaching that. They did not even do it during their times at school. It’s something that was brought in as a crash program for teachers to be taught as well (P61:3).

One of the key characteristics in RME is that learning strands should be intertwined (Drijvers & Doorman, 1996, p. 429). Learners ought to have a cohesive view of Mathematics and the way different topics are associated with each other and fit into one curriculum (Widjaja & Heck, 2003, p. 5). One participant expressed his desire to also learn progressively across grades and across the curriculum:

The thing is I started learning probability when I was teaching grade 12. After xxx left, then I took over. So I wanted to do it from grade 10. So this is how now I’m learning, right from grade 12. Because if you’re teaching it at grade 12, there are some of the concepts that you don’t know at the grade 11 and grade 10 level (P49:8-9).

The content they found the easiest to relate to real life was Calculus, Probability, Integers, Data Handling, Measurement and Financial Mathematics:

Because we are working with money every day (P49:16).

Through and through it every day life situations where you talk of borrowing, investments and other areas of activities (P61:8).

A reason offered for poor learner performance in Mathematics was that learners dislike Mathematics because they are not learning relevant and significant content (Fauzan et al., 2013, p. 162). The study aims to make participants more aware of the need to relate the content that they teach in Mathematics to real life situations. I therefore asked them which areas they needed help with to relate the content to real life. The content areas where they needed help to relate the content to real life were: the application of Calculus; exponents, algebra, functions; integers; counting principles. Although the participants considered Financial Mathematics and probability as topics that can easily be related to real life situations, they also felt that they needed help to relate those two areas to real life situations.
4.2.3 Learner Aspects

One of the participants likes to use peer teaching in her classroom. She pointed out the benefits that her learners experienced:

Yes, the learners present and they present it so well, they present it so well. In the meantime they are also learning, you understand? They are also learning. So, I also tell some other learners they must also do it, because you gain more knowledge by just standing there and going home to prepare the topic to do it. They come prepared and then they do it so nicely (P60:85).

Cahyono (2012) indicated that by interacting with each other, learners can enhance their understanding of mathematical concepts and the way in which they relate to real life (§ 3.2.7).

4.3 The Facets of Realistic Mathematics Education

Participants discussed various aspects that highlighted the facets of RME that are present in their teaching. This section includes a discussion on the characteristics of RME; certain aspects of RME; and the advantages of RME. Figure 4.4 indicates the coding structure that represents the framework for this discussion.

![Figure 4.4: Coding Structure for the Facets of Realistic Mathematics Education as Highlighted by the Participants](image)

4.3.1 Characteristics of Realistic Mathematics Education

Participants raised a number of factors that related to the characteristics of RME. As discussed in Chapter Three, the systematic literature review revealed various authors that have discussed the characteristics of RME. These characteristics include: the use of contextual problems; the use of models; student contributions are encouraged; interactivity; and the intertwining of learning strands (Drijvers & Doorman, 1996).
A crucial aspect of RME is when students are able to solve problems in realistic contexts which they
deeem as relevant (Boon, 2006). The participants expressed their views about the importance of
referring to real life situations when teaching Mathematics:

Definitely, it is more important to relate it to more real life situations (P49:24).
Because if you relate it to real life situations, it becomes easier for them to understand and they
can also relate other things to the topic that you are teaching (P59:29).

Context problems should be the mooring points for students to learn and reinvent Mathematics
(Stephan & Akyuz, 2014). The value of using real life situations should therefore not be
underestimated. Participants expressed their views about the importance of relating Mathematics to
real life:

Because then we are linking the new work to something that they are familiar with (P60:26).
Like, I said, some of the learners they don’t know, when you’re playing football or any other
sports, Maths is applicable everywhere (P49:25).
When they are sleeping, when they get up, Maths is applicable to them, every way, they don’t
know that, so they take it as something that is very special, they put it aside (P49:27).

When designing learning activities, teachers should remember that the activity should encourage the
students’ work with Mathematics (Andresen, 2007). The teachers’ role in the design of instructional
material is crucial: they need to anticipate supportive mathematical imagery; create challenging
assessment; use their mathematical knowledge to improve on the instructional sequence; and rework
existing tasks (Stephan & Akyuz, 2014). Participants indicated a few examples of how real life
situations can link with mathematical content:

In most cases that had to do with gradient. The gradient of that particular road is not evenly
balanced. In mathematical terms that has to do with gradient (P61:7).
It appears as if there is no link but calculus it also talks about gradient and so forth. That is real
life situations (P61:11).
Uhm, in Financial Mathematics as well. Through and through it every day life situation where
you talk of borrowing, investments and other areas of activities (P61:8).

Modelling activities should come about in situations and contexts that are experientially real to the
students (Doorman et al., 2008). The problem situation should set models in motion that initially
represent the problem situation, but have the potential to develop into a more general model (Bakker
et al., 2003). One participant clearly emphasized this aspect of RME:

So, you cannot do Mathematics without modelling. And, once you talk about modelling, you are
now talking about real life situations (P61:12).

The starting point for learners’ learning should be real contexts that are meaningful to them. These
situations should be used as the basis for concept formation which leads to more formal Mathematics
(Widjaja & Heck, 2003). One participant acknowledged the importance of choosing a context that is
experientially real for those particular learners:

So it is difficult to relate this to somebody who doesn’t know about the situation (P49:21).

Interactivity is promoted when learners are more accountable for their own learning (Widjaja & Heck,
2003):
And especially sharing those ideas of Mathematics, it will help a lot (P59:57).

As was mentioned in § 3.3.2, the intertwining or integration of different strands or topics is an essential part of RME (Widjaja & Heck, 2003). Participants encourage this integration.

Because then we are linking the new work to something that they are familiar with (P60:26).

Another participant diagnosed a challenge that learners had with integration and also acknowledged the misconceptions that can develop due to a lack of integration:

We have a problem in functions, but the problem emanates from the fact that they don’t understand for example exponential function—if learners don’t understand how to solve exponential equations then when you go to functions it becomes very difficult (P61:1).

4.3.2 Aspects of Realistic Mathematics Education

The two aspects of RME that were evident in the discussion with the participants were that Mathematics is considered to be a human activity (Freudenthal, 1971); and that problem solving should be done in realistic contexts (Gravemeijer & Doorman, 1999). Freudenthal (1971) advocated that for Mathematics to be of human value, it needs to be useful, i.e. closely linked to reality. One participant used the example of children playing football, and how that could link to Mathematics:

Like, I said, some of the learners they don’t know, when you’re playing football or any other sports, Maths is applicable everywhere (P49:25).

As mentioned in § 4.3.1, it is important when implementing the principles of RME that we pose problems in realistic contexts, that learners recognise as relevant and real (Boon, 2006). One participant indicated that by following that teaching approach, finding relevant contexts could be challenging. He indicated that what might be familiar to learners in urban areas, might not be relevant to learners in rural areas. In the example that he used, he pointed out that not all learners were familiar with the Kentucky™ fast food franchise, and that teachers should be cautious when deciding on an appropriate context for the learners that were in their classrooms:

You see, most of our learners they are not, how can I say it, they are not familiar with the situations. Like for instance you cannot just ask somebody from the farms about Kentucky, you see? So it is difficult to relate this to somebody who doesn’t know about the situation (P49:17-21).

One of the participants expressed his opinion that certain content areas were well-suited to real life situations:

Some of the topics, they come clear to real life situations (P49:13).

He as well as another participant also pointed out that not all areas were easy to connect to realistic contexts:

It’s difficult to relate (P49:14).

Hmm, there are topics that we can relate to real life situations, the others they are a little bit more confusing or difficult to relate (P59:17).

A third participant pointed out examples of a realistic context that could be used to relate the content
area of Financial Mathematics to reality:

Uhm, in Financial Mathematics as well. Through and through it is an everyday life situation where you talk of borrowing, investments and other areas of activities (P61:8).

The participants also expressed their ideas about which content areas they found easy to relate to real life. These were Calculus, Financial Maths, Probability, Integers, Data handling, and Functions.

4.3.3 Advantages of Realistic Mathematics Education

In Chapter Three, I pointed out various advantages that are expressed in the literature regarding the use of RME principles (§ 3.3.5.1). These include: improvement of learner motivation (Cahyono, 2012); a more positive attitude towards Mathematics (Fauzan et al., 2013); and interactivity and collaboration are promoted (Widjaja & Heck, 2003). A participant also suggested that by using real life examples, learner understanding could possibly be improved:

Because if you relate it to real life situations, it becomes easier for them to understand and they can also relate other things to the topic that you are teaching (P59:29).

4.4 Ideas and Considerations about Information and Communication Technology

In this section I will discuss the considerations and ideas of the participants relating to ICT that were revealed in the individual interviews. I discuss this section as five main themes, namely the value of using ICT; challenges when working with ICT; various technology devices; the manner in which technology can function as an educational tool; and ICT factors that relate specifically to the participants. Figure 4.5 illustrates the network view of the coding structure for the participants’ considerations and ideas about ICT.

![Figure 4.5: Coding Structure for the Participants’ Considerations and Ideas about Information and Communication Technology](image)

4.4.1 The Value of Using Information and Communication Technology

In relation to the integration of technology in teaching, Drijvers et al. (2010a) describe the role of the teacher as both critical and problematic (§ 3.4.1). The teacher’s role is critical because the teacher’s
approach to using technology has far-reaching effects in the classroom. It is problematic because teachers have difficulty in adapting their teaching strategies when working with technology. The participants pointed out positive aspects of using technology in their experience. This is a promising aspect since the teacher’s role is so crucial in implementing the use of technology in the classroom.

With reference to the Interactive Whiteboard (IWB), the participants said:

Because if you are prepared, it could save time. You don’t have to write again. As long as you prepare in time, then you just put your preparation there and you go on, so a lot of time will be saved (P59:64).

It would be much beneficial for example if I use the interactive whiteboard, almost all learners like it at our school. The whole generation of today, they can all use computers (P61:37).

With reference to the overhead projector, they said the following:

It was easy to use them, rather than making use of the chalk. We could prepare in advance (P49:33-34).

But all in all it’s too beneficial to use technology. It also saves time, instead of you writing notes on the board for one hour, it’s easier using the technology (P61:40).

4.4.2 Challenges while Working with Information and Communication Technology

Participants expressed their concerns and challenges concerning the use and integration of ICT in their teaching of Mathematics. We should keep in mind that the literature review revealed that using technology in Mathematics education does not provide instant improvement (Drijvers, 2013). Challenges will therefore always exist. One of the participants expressed his concerns about the use of calculators in the lower grades:

What about these calculators? Because with the grade eight, let me say grade six, seven and eight, I think that using calculators is not good. Because they tend to...how can I put it—to lose those skills, calculating skills or basic skills of Mathematics. Even a simple problem, they want to use a calculator instead of doing it themselves (P59:68).

When I asked him about using calculators in higher grades, the same participant said:

No, no, calculators at least with them, it saves time. Because there, they are doing more complicated things. For example with financial Maths, they have to use a calculator (P59:70).

Another challenging area that the participants discussed related to proper training on the use of technology in the Mathematics classroom:

There was training, and then the department sent someone from them to come. But, it was not only for Maths (P60:33).

Yes, they have the tablet. We have the interactive whiteboard, but we the teachers are still struggling to use the interactive whiteboard. Most especially for Maths. They say that somebody from the department will come and help us (P60:8).

Further challenges that concerned the participants related to poor infrastructures and facilities:

At present we don’t have technology devices at our school, but I think those devices if we can have those devices they are going to help us...because it will ease the burden (P59:31).

Ja, last time when we were using the overhead projectors, but now the state of our school we cannot, we have so many projectors here, but they are not functioning (P49:34).

General concerns that they expressed had to do with their experiences and perceptions of technology:
Yes, and my experience as well is that learners might be fascinated with the use of the computer and the overhead for one or two days, then they will lose interest. That is my experience (P61:26).

You can say cell phones are not designed for teaching and learning, it’s just for communication purposes, so if you use them for teaching and learning, I don’t think it’s a good idea, unless if you want to communicate with them, send them homework, maybe the results, something like that (P59:37).

4.4.3 Devices

Two participants pointed out the benefit of working with an Interactive White Board (IWB):

Yes and I can also save my lessons. I can even use it next year for the other groups (P60:54).

It would be much beneficial for example if I use the interactive whiteboard, almost all learners like it at our school. The whole generation of today, they can all use computers (P61:37).

Because in our interactive whiteboards there are pre-recorded lesson (P60:58).

For me, to be able to create a suitable intervention tool, that all participants would have access to, it was necessary to establish which devices the student-teachers would be willing to use. They indicated that they were happy to use the following devices: IWBs, mobile phones, tablets, laptops and desktop computers. Since mLearning is a rapidly expanding field that provides new opportunities for education (Kizito, 2012a), and as the participants indicated their willingness to work with mobile devices, I therefore decided to design a mobile app as an intervention tool. Some of the advantages that mobile devices offer were discussed in § 3.4.3. These include the following: mobile devices offer the potential for stimulation, motivation, availability as well as ease of use (Zaranis et al., 2013). A detailed description of the mobile app is presented in Chapter Five.

4.4.4 Technology as an Educational Tool

The use of WhatsApp™ for groups of learners is said to have various advantages in the educational arena (Barhoumi, 2015, p. 223). The technical advantages of WhatsApp™ include: simple operation; low cost; availability; and immediacy (Bouhnik & Deshan, 2014, p. 217). One participant makes use of WhatsApp™ groups with her Mathematics classes and relies on the immediacy that it offers:

So, I usually take the answers, then I sometimes take a camera, and then I send it to them (P60:41).

The educational advantages include creating a pleasant environment and in-depth acquaintance with fellow students (Bouhnik & Deshan, 2014, p. 217). The academic advantages are accessibility of learning materials; teacher availability; and the extension of learning after class hours (Bouhnik & Deshan, 2014, p. 217). The participant confirms these aspects of teacher availability and extended learning:

We’ve got a group WhatsApp™. If there is maybe something that they don’t understand, we chat (P60:36).

Yes, like I give them homework, somebody’s stuck along the way they don’t have any, you know they don’t have many resources even to refer to. I will give them one or two tips on how to continue with the problems (P61:29).

Participants referred to other forms of technology that are used as educational tools. The participants
referred specifically to the use of web-based interactives and GeoGebra:

*With a computer, I think there are other programmes which might help. When I was doing ACE in Potchefstroom, there are those programmes where you will be tested on a certain topic. Then the computer will immediately correct you and show you how to do this problem if you are doing it wrongly (P59:66).*

*If you want to show a learner that the angle at the centre is double the angle at the circumference attended by the same chord for example, you can do it by technology (P61:16).*

Tablets are another form of mobile technology that is becoming a popular educational tool. The benefits of using tablets include: ease of use; anywhere, anytime learning; a variety of educational apps are available for use; teachers' workload can be reduced with digital collection and marking of tasks; and greater autonomy of learning (Churchill, Fox, & King, 2012, p. 252). Participants also referred to the use of tablets in the classroom:

*Some of the questions, previous question papers are there with memos, and they can research, they can do whatever they want there. It’s off-line at night, but during the day it’s on-line (P68:14-15).*

### 4.4.5 Participants' Information and Communication Technology Factors

The participants in general are positive about and can benefit from the use of technology in various ways:

*Yes, I am eager I am eager you know, to let them come and use that (60:72).*

*I’d be willing to use it with other colleagues to discuss tasks related to Maths (P59:42).*

*I’m using a computer at my home (P60:45).*

However, a number of challenges remain:

*I don’t have time for social media (P49:44).*

*My email is not working, but I will try to fix it (P49:65).*

### 4.5 Role players

In this section I discuss four role players that emerged in both the literature and in the interview data. These are teachers, learners, the community and the context. Figure 4.6 illustrates the coding structure that I used for this data analysis.

![Figure 4.6: Coding Structure for the Role of Various Role players in this Study](image)

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Although teachers and learners could benefit from the use of technology, not all stakeholders share the optimism about how ICT can effectively be used in teaching and learning (Drijvers et al., 2010a; Heck et al., 2007). Widjaja and Heck (2003) and Zulkardi (2000) affirm the changing role of teachers and learners in the RME classroom. These issues can account for the increased pressure on the various role players in education. The participants expressed their opinions on the topic.

4.5.1 The Role of the Teacher

Various issues were raised that related to the role of the teacher. Firstly, the challenging task of a Mathematics teacher was emphasized:

Ja, so it’s difficult to teach Maths, very difficult (P49:31).

Yet the participants’ enthusiasm was tangible:

I’m excited (P60:28).

A common belief exists that teachers teach the way they were taught. Dunn and Dunn (1979, p. 241) rather believe that teachers teach the way they learned, and that their teaching style is directed by learning styles. One participant also raised this issue:

But how I think is also influenced by the way I was taught myself although I have changed a bit (P61:13).

The participants also raised challenges that they experience in terms of time and professional development:

Time is a problem, because now I’m having extra classes with the grade elevens on Wednesdays and also on Saturdays. I don’t have time for social media (P49:43-33).

I feel that maybe if I can maybe have more knowledge (P60:31).

4.5.2 The Role of the Learner

Since the study was more focused on the perceptions of the teachers, few aspects relating to learners were revealed despite social and contextual circumstances that can negatively influence learners’ learning (Considine & Zappala, 2002, p. 130). One participant testified to the poor socio-economic status of their learners:

But, maybe only, let me say ten percent of our children have got a good background, they have got a satellite dish. So mostly they are from shacks, where they do not have electricity, you know... (P60:77).

4.5.3 The Role of the Community

The role of the community should not be underestimated. Community demographics affect how students perform in Mathematics (Sackey, 2014, p. i). The participants shared their experiences of the community:

Yes, because I once asked them to watch that learning channel. Then I realized that most of our learners, 90% of them don’t have that. Some they have the TV, but they don’t have the
dish, they can’t afford to pay the dish every month (P60:78).

If learners have supportive relationships with their parents, it positively influences learner motivation (Wentzel, 1998, p. 206) and academic performance (Makgato & Mji, 2006, p. 261). Despite often being aware of this, parents are rarely involved in their children’s schooling (Makgato & Mji, 2006, p. 261). The participants touched on this aspect in the discussion:

It goes back to what I said; there are so many factors within the community which are inherent on how this will work. I did not think that I had enough support from their parents. Because learners in their own, they have a lot of things they need to do (P61:30).

Even their parents, they are worse than these learners (P49:29).

4.5.4 The Role of the Context

There is a definite link between the quality of school facilities and student achievement (Uline & Tschannen-Moran, 2008, p. 55). Participants point out the challenges they experience with regard to the school facilities:

And some of the classes do not have electricity. That’s another problem (P49:35).

You have a situation here where there is no electricity in the community, electricity is gone. But, for me I think through my experience, I have tried both electronic and the traditional. I think they should all be used concurrently in such a way that for example after using the traditional one, you can move onto technology so that the learners can understand it better (P61:38).

Unfortunately at the moment, because we have only one interactive whiteboard in one of the computer labs. So, any specific teacher who wants to use it will have to discuss it with other teachers when and so on. So, I have not agreed to having a class with them because of the congestion of the program of the curriculum. Because for example in grade 10 we have nine classes, grade 11 around seven, grade 12 we have close to two hundred learners. It has not been easy (P61:35).

Howie (2003, p. 2) suggests various factors for the poor performance of learners in Mathematics in South Africa in particular. In relation to institutional issues these include “the lack of professional leadership; heavy teaching loads; overcrowded classrooms; poor communication between policy-makers and practitioners; and a lack of professional staff in the ministry of education.” So too did the participants highlight aspects relating to the higher structures that they found problematic in their teaching practice:

For example with Euclidean geometry, the curriculum statement does not give the teacher the opportunity for learners to discover where these theorems are coming from (P61:15).

Since the department said that every grade 12 teacher must have a laptop, but we are still waiting for them to give that to us, the laptop (P60:44).

We even went to the workshop, but you know those workshops are only for three days. And we were doing so many things—we were doing geometry because they also introduced geometry. But we did it in our times—those theorems. Yes, all of us feel that it was not enough training, really it was not enough (P60:3-5).

4.6 Chapter Summary

In this chapter I presented a detailed analysis of the interview data that were generated to establish
what needs the participants had in terms of teaching Mathematics in a more realistic way. I firstly explored the participants' needs in terms of Mathematics itself, and started by focusing on factors that influenced teaching and learning. An aspect that emerged that was very reassuring was the desire of the participants to move forward and improve as teachers. Their aspirations were evident not only in that they are currently improving their qualifications, but they also expressed the desire to be involved in professional development and training. Other aspects that they raised regarding factors that influence teaching and learning were twofold. They discussed the importance of establishing good Mathematical foundations when teaching and also mentioned the significance of providing learners with immediate feedback.

This chapter also presented a discussion on the problem areas that learners had, as well as challenges that teachers faced regarding the content of the Mathematics curriculum. Literature has pointed out that a possible reason for learners' poor performance in Mathematics is that the content is not presented as relevant and significant. I therefore explored areas that the participants had difficulty in making the content realistic, relevant and significant for their learners. This would help me in designing a relevant and appropriate intervention tool.

Since this study is deeply entrenched in the theory of RME, it was essential to touch on the characteristics of RME in this discussion of the data. All five characteristics of RME emerged in the data as participants discussed the importance of interactivity, modelling, integration between strands, the use of realistic contexts and learner participation. These characteristics all featured strongly in the discussion with the participants. Apart from the characteristics of RME, I further explored two aspects related to RME, namely that Mathematics is considered to be a human activity and the importance of real life examples in Mathematics teaching. This led to a discussion on the advantages of using real contexts to improve learner understanding, which literature has shown us.

Apart from Mathematics and RME specifically, the other main theme that underpins this study is the use of ICT in teaching and learning. This chapter also detailed the teacher-students' considerations and ideas about ICT. I discussed their ideas regarding the value of ICT and the critical role that teachers play in the integration of technology in teaching. I further explored the challenges raised by the participants. These included concerns about using calculators in the lower grades; the lack of technological training that the participants experienced; the poor infrastructures and facilities that they had to deal with which impacted on their use of ICT; and general experiences and perceptions that the participants shared about ICT. They also discussed their ideas and experiences about different technological devices such as the Interactive Whiteboard. In order to successfully incorporate technology in the intervention stage of this study, it was important for me to establish which technology they were most comfortable with. The participants shared their ideas on this topic and clearly indicated their preference for mobile technology. This informed my choice of technology for the design phase of the study. I also explored their ideas on technology as an educational tool. They shared their experiences of working with WhatsApp™ groups, GeoGebra, web-based interactives and tablets.
The final stage of this chapter dealt with the four role players that featured in the discussion with the participants, namely the teacher, learner, community and context. In the interviews, the participants reinforced the notion that teaching Mathematics was a challenging task, yet their enthusiasm to be Mathematics teachers was evident. They expressed their opinions on challenges they experienced in terms of teaching styles; time and professional development. The most dominant aspect relating to learners that featured was the effect of a poor socio-economic status on their learning. The role of the community and the context was also discussed and participants shared their views on aspects such as the crucial role that parents play in the children’s education; the effect of poor school and home facilities on learner achievement and the influence that decisions by authorities had on teaching and learning.

Chapter Five presents the design of the intervention tool. In this chapter I discuss in detail the purpose of the mobile tool; and the design process. When discussing the purpose, I explored the theory of mLearning, the connection between technology and RME and also the context for which the tool was designed. In the discussion on the design process, I expanded on the theoretical aspects of the design process and also the technical facets of the design process.

As was discussed in § 2.4, upon completion of each stage of a design-based research project, researchers will perform systematic reflection and documentation to produce the required scientific yield in the form of theories or design principles (Plomp, 2007, p. 15). As is illustrated in Figure 2.6, upon completion of the needs and content analysis phase, I have produced a number of design principles relating to that phase. The design process led to the realisation of a number of principles that were established in the needs analysis phase. These principles are presented in Table 4.1.

Table 4.1 Design Principles for the Design of a Mobile App Based on the Principles of Realistic Mathematics Education Derived from Individual Interviews with Participants

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Implications</th>
</tr>
</thead>
</table>
| Determine participants’ needs in terms of teaching Mathematics | • Establish what needs the participants have with regard to content areas (both teachers and learners)  
• Establish participants’ needs in terms of making Mathematics realistic for the learners |
| Establish the participants’ eagerness for being mentored | • Participants should indicate a desire to be involved in professional development  
• Participants must aspire to move forward |
| Adhere to the characteristics and principles of RME | • Meaningful, realistic contexts should be the foundation for students to reinvent the Mathematics  
• Student contributions should be encouraged  
• Incorporate the use of modelling  
• Make use of interactivity  
• Ensure the intertwining of content areas and concepts |
| Establish participants’ views about ICT | • Participants should see the value of ICT  
• The challenges that participants experience with regard to ICT should be addressed as far as possible  
• Establish which devices the participants find most suitable |
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Implications</th>
</tr>
</thead>
</table>
| Determine which role players feature most prominently within the context | - Teachers are the key role players in integrating ICT in teaching and learning  
- Learners’ learning is influenced by their socio-economic circumstances  
- Parents play an essential role in learners’ academic performance  
- Facilities and higher authorities can be important within the given context |
|  Determine in what manner participants use technology as an educational tool |  
|  Teachers are the key role players in integrating ICT in teaching and learning  
|  Learners’ learning is influenced by their socio-economic circumstances  
|  Parents play an essential role in learners’ academic performance  
|  Facilities and higher authorities can be important within the given context |
Chapter Five
The Design and Development of the Mobile Intervention Tool

5.1 Introduction

A purpose of this phase of the investigation was to establish the support needs of teachers in order to effectively implement the RME approach in their teaching practice. After doing individual interviews with students (Chapter Four), I established the areas in which they needed assistance, not only with their teaching, but also in making Mathematics more realistic for their learners. To address these areas of need, it was necessary to design an intervention tool for the teacher-students to use, based on the principles and characteristics of RME. Figure 5.1 illustrates the structure that will be followed in this chapter.

![Figure 5.1: Advance Organiser for the Design and Development Process of the Intervention Tool](image-url)
5.2 The Purpose of the Mobile Tool

MLearning has made a valuable contribution to the educational environment in recent years (Alzaza & Yaakub, 2010, p. 95). Mobile devices are stimulating platforms for learning due to their computing ability, their affordability and their ubiquitous nature (White & Martin, 2014, p. 95). The teacher-students in this study shared their perceptions, experiences and needs regarding the academic content and the effective implementation of the RME approach in their teaching practice (Chapter Four). They confirmed inter alia that they were excited about the use of mLearning to address the issues and needs that they faced in their teaching, specifically relating to content and linking school Mathematics to real life situations. I therefore deemed a mobile tool, in the form of an app, to be suitable for the teacher-students in order to present the mathematical content and principles of RME to them.

5.3 Theoretical Underpinnings for the Design Process

In this section I discussed some of the theoretical underpinnings that drove the design of the app. I investigated relevant literature relating to mLearning in general and probed aspects relating specifically to the design and use of mLearning in Mathematics. I also briefly mentioned the link between technology and RME. A detailed discussion of this literature concerned with ICT and RME was done in the systematic literature review in § 3.4.5.

5.3.1 Mobile Learning (mLearning)

Literature offers various definitions for mobile learning. MLearning is learning realised with the aid of a small, portable computing device, which typically involves the viewing of content or lessons in manageable chunks (McConatha, Praul, & Lynch, 2008, p. 15) as a specific type of learning model for using mobile technology (Cheon, Lee, Crooks, & Song, 2012, p. 1054). Sharples (2013, p. 2) provides various definitions for mobile learning. He highlights one definition that encompasses both perspectives of learners’ mobility as well as learning with portable technology as that of O’Malley et al. (2003, p. 7), which states: “Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies.”

Mobile technology offers a new generation of learning to people of all ages without being bound by place and time (Alzaza & Yaakub, 2010, p. 95). MLearning is becoming more popular within formal education as its benefits are widely publicised as being cost effective and flexible in terms of time and location; it is a ubiquitous form of communication, and can serve as a study aid (Cheon et al., 2012, p. 1054). Cheon et al. (2012, p. 1054) summarise the characteristics of mobile devices into three aspects: the portability; instant connectivity; and context sensitivity.
Al-Emran, Elsherif, and Shaalan (2016, p. 94) list the benefits of mLearning for students: it enhances collaboration between learners with each other as well as with their educators; it facilitates team collaboration; the sharing of knowledge; and raising of technological awareness. MLearning assists students to create social interaction; it promotes collaborative learning, interactivity and instant feedback as well as collaboration between peers; it improves their knowledge structure; their learning achievements (Domingo & Garganté, 2016, p. 22; Mouza & Barrett-Greenly, 2015, p. 3) and motivation (Mouza & Barrett-Greenly, 2015, p. 3). Domingo and Garganté (2016, p. 22) further point out that students are more willing to engage when learning with mobile technology; their desire to accomplish educational tasks also increases with the use of mobile technology; and it helps learners to be more self-directed in their learning. Mobile communication in education is a solution with a selection of prospects and challenges (Kommers & Hooreman, 2009, p. 88).

mLearning applications have various educational benefits: they can be used as study aids; can be accessed from almost anywhere; and with the aid of location capabilities, students can use location-based information (Cheon et al., 2012, p. 1054). Mobile technology apps enrich higher education by extending traditional educational platforms and encouraging distance learning or settings outside of the classroom (Al-Emran et al., 2016, p. 94). Content applications that make use of personalized instruction can facilitate academic growth and self-efficacy among students (Mouza & Barrett-Greenly, 2015, p. 12). In their paper on the professional development of teachers, Mouza and Barrett-Greenly (2015, p. 13) note that professional development that is grounded in recognised best practices is essential in assisting teachers to obtain the knowledge and skills they need to fully benefit from mLearning.

The use of mLearning has become essential for higher education due to its numerous benefits (Al-Emran et al., 2016, p. 94). Increased affordability and functionality has made mLearning more attractive in education (Domingo & Garganté, 2016, p. 21). Jantjies and Joy (2015, p. 308) are of the opinion that mLearning apps used in subjects such as Physical Science and Mathematics require appropriate content that considers the users’ challenges and needs.

In recent years, there has been a tremendous increase in the use of tablets and smartphones in the educational arena (Calder, 2015, p. 233). Tablet computers provide new potential for Mathematics learning, (Zhang, Trussell, Gallegos, & Asam, 2015, p. 32). Tablets offer the following benefits: they are light; they are portable; most tablets have a long battery life; and they offer a positive sensory experience to children. They also allow learners to do Mathematics tasks at their own pace; and provide immediate feedback (Zhang et al., 2015, p. 33). Immediate feedback is one of the aspects that teacher-students in this study identified as an essential aspect of teaching and learning in the individual interviews (§ 4.2.1).
5.3.2 Mobile Learning (mLearning) in Mathematics

The use of digital technology in Mathematics education allows for improved engagement with mathematical processes and concepts (Calder, 2015, p. 233). Specifically, mLearning affords new learning opportunities in Mathematics (Graven, 2011, p. 45). Mathematics apps are an effective way in which learners who struggle can be provided with instructional support (Zhang et al., 2015, p. 38). They allow students to solve more problems than when using paper and pencils; they are easy to use; and are generally able to actively engage students (Zhang et al., 2015, p. 38). Students’ experiences with mobile devices are often more rewarding than teachers may realise (Lee & Kautz, 2015, p. 575). When learning Mathematics, students have the opportunity to explore and take risks with digital technology, which is not always otherwise possible (Calder, 2015, p. 238).

Cayton-Hodges, Feng, and Pan (2015, p. 3) report on a survey of Mathematics apps available in the Apple App Store. The intention of the survey was to learn what should and should not be done in the development of Mathematics assessment in the apps. They mention various aspects that should be considered in the design of Mathematics apps. There should be a rich and accurate representation of the mathematical content; the interactions around the mathematical content should be lavish and engaging; there should be an opportunity for users to reflect on tasks they have done; and hints, scaffolds and other tools are important and are typically presented on a need to know basis (Cayton-Hodges et al., 2015, p. 16).

Lee and Kautz (2015, pp. 576-577) present a framework for the design and implementation of mathematical tasks with the aid of mLearning. The framework consists of six steps, which do not have to take place chronologically. The purpose of the framework is to provide structure, specify components and indicate the relationships between technology-based task design and implementation. The steps are as follows: define the lesson objective; define the technological environment; define the types of investigations; design and develop the tasks; implementation; and enactment (Lee & Kautz, 2015, p. 577). Figure 5.2 illustrates the framework suggested by Lee and Kautz (2015) which focuses on the aspects that need to be considered and the actions that need to be taken when incorporating mobile technology into Mathematics teaching and learning.

![Figure 5.2: Framework for mLearning task design and implementation (Lee & Kautz, 2015, p. 577)](image-url)
Students and teachers alike generally find apps engaging and motivating, and promote their inclusion in programmes. This might partly be due to the fact that learners today are captivated by digital media, and are able to use these to communicate, investigate and process ideas very effectively (Calder, 2015, p. 246).

5.3.3 The Relationship between Technology and Realistic Mathematics Education

Drijvers et al. (2010b, p. 89) describe the integration of technology into the teaching and learning of Mathematics as urgent. The fundamentals of how Mathematics should be taught are challenged by the incorporation of technology in Mathematics education (Olive et al., 2010, p. 138). Digital technology in Mathematics education has the capability to allow students to construct and engage with mathematical knowledge which allows for the subject to be entrenched in authentic contexts and sanctions the creation of meaning for the students (Bray, Oldham, & Tangney, 2015, p. 2489). Technology can be used as an effective facilitator in the implementation of the RME approach (Widjaja & Heck, 2003), and using technology in the RME approach produces better results than traditional teaching (Zaranis, 2013). As discussed in Chapter Three, it is essential that digital technology be incorporated in different contexts in a natural way (Drijvers, 2013) (§ 3.3.3.6). So too should the context be chosen in such a way that the technology can aid the process of mathematization (Boon, 2006). Technological environments have the prospect of reconnecting the learners with authentic contexts in which they can create meaning (Olive et al., 2010, p. 138). The use of technology also places the emphasis on the “practice and applications of mathematics through visualisation, manipulation, modelling, and the use of mathematics in complex situations” (Olive et al., 2010, p. 139).

5.4 The Context for which the App was designed

The app was designed to assist teacher-students with the challenge of making the mathematical content more realistic for their learners. The teacher-students are in-service teachers from both rural and urban environments. They are enrolled for the BEdHons programme in Mathematics education which implies that they either have a first degree or a certificate such as the Advanced Certificate in Education (ACE) with Mathematics as specialisation area. They all share the common desire to improve their qualifications. The teacher-students are older than the average student since they already have a prior qualification and are required to be employed full-time as teachers. They often have family commitments along with the commitments of full-time teaching and part-time studying. The majority of the students teach at disadvantaged schools and are women (Kok, 2009). The participants in this study agreed that they were willing to use technology to take part in the project, and all agreed that mobile technology was a suitable method of communicating and delivering material within the context of this study (§ 4.4.3). It was therefore appropriate within the context of this study to design an app as an intervention tool.
In the 2016 ECAR Educause survey performed at the North-West University, 68% of students were found to have android devices, 21% to have iOS, 8% to have a windows device and 3% to have other devices (Dahlstrom, Brooks, Pomerantz, & Reeves, 2016). It was therefore fitting to design the app for Android devices since the majority of students own an Android device.

5.5 The Design Process

The process of designing the app required a team effort. The team consisted of an experienced programmer that designed the app; myself, who featured as the content specialist and also the creator of the design documents; my promoter, an expert in the field of using technology in teaching and learning, and who also oversaw the design process; and my assistant promoter, an expert in the discipline of Mathematics as well as Mathematics education, with a keen interest in the use of technology in Mathematics education. Various theoretical and conceptual aspects as well as specific technical aspects guided the process. The app consists of two main sections: a content section and an activity section. In the content section the mathematical content is presented in a systematic way. The progression of the topic is done methodically to assist those users who are not completely au fait with the content. The second component in the app is an activity section, where the concepts that were presented in the content section are reinforced and also extended to new and challenging situations.

5.5.1 The Theoretical Aspects of Creating the App

McKenney and Reeves (2012, p. 78) state that the process of design-based research starts with an analysis of the existing problem in educational practice and is often supplemented by literature to establish a proper understanding of the problem. In Chapter Two, Figure 2.6 illustrates the design process specific to this study. A detailed discussion of the research design methodology is presented in Chapter Two. After the completion of the systematic literature review and the needs analysis interviews with the teacher-students, the first phase of the design process for this study was completed.

After the needs analysis interviews with the teacher-students had been done, the data were coded, classified and analysed. The detailed analysis was described in Chapter Four. Teacher-students shared their perceptions and experiences relating to what support needs they had in terms of effectively implementing the RME approach in their teaching practice. The data analysis revealed the content areas that the teacher-students and/or their learners had difficulty in understanding. The topics which all four respondents experienced as problem areas were Financial Mathematics; Geometry; Probability; Algebra; Integers; Counting techniques; Graphs; Functions; Calculus and Trigonometry (§ 4.2.2). The participants shared that they needed help in relating the following content
areas to real life: Calculus; Exponents; Algebra; Functions; Integers; Financial Mathematics; Probability; and Counting principles (§ 4.2.2). I selected to design and develop a mobile app for the content area of Financial Mathematics because this topic featured in both categories discussed above. This process encompasses the needs and content analysis stage of the design process as presented in Figure 2.6.

The second phase of the process (Figure 2.6) relates to the design development and evaluation phase. Solutions informed by existing design principles and innovations in technology comprise the second step in the process (Amiel & Reeves, 2008, p. 34). To implement this phase, I approached a programmer who is experienced in mobile app development to design and construct the intervention app. An initial discussion took place between my promoter, the programmer and I where we discussed the possibilities and requirements for designing the app. I then proceeded to draw up a first draft of the app design document (Addendum 5.1). This document provided the programmer with a broad idea of the content of the app. It also outlined the tasks, hints and instructions in detail, as well as some notes to the programmer on how I wanted the app to work. The initial draft of the app design document was perused by my promoter and sent to the programmer before he developed a first prototype of the app. Figure 5.3 illustrates the screenshots of the first prototype of the app.
My promoter and I met with the programmer once the first prototype was designed. We discussed further expansion of the app and looked at possibilities that were viable within the parameters of the study. These factors were also discussed with the assistant promoter, who gave guidance particularly in the areas of the mathematical content and the principles and characteristics of the RME approach. After this discussion, I edited and extended the app design document for the further development of the app. A third meeting was arranged between the other three experts involved in the design of the app. At this meeting the second prototype was presented and discussed. The assistant promoter also provided input and feedback on the second prototype. Plomp (2007, p. 15) states that experts or users can be involved in the testing of the prototypes. In this case the first and second prototypes were tested by the promoters, me and the programmer.

The final evaluation and reflection stage forms the third step of the design-based research process (Figure 2.6). This involves iterative cycles of refinement of solutions that are implemented in practice (Amiel & Reeves, 2008, p. 34). To refine the app further, I asked an RME expert, who is extensively experienced and qualified in both Mathematics and Mathematics education to evaluate the third prototype of the app with the specific focus on the inclusion of the RME principles and characteristics. His evaluation revealed that the principles and characteristics were sufficiently included in the app. He further added that the app should achieve the purpose for which it was created, which is to assist teacher-students with making the teaching and learning of Mathematics more realistic for their learners. He suggested that the app be tested before being released for the teacher-students to use.

This suggestion was followed up and duly done—the app was further tested by two Mathematics education experts. Their main suggestion to improve the app was to expand on the initial problem situation, and make it more understandable to the user:
Their evaluation also reinforced the need to create the app and confirmed its suitability for teacher-students:

*It works very well because all the steps are clearly shown. It will help the teachers to teach their learners to follow logical steps in their calculations.*

The app included an activity that clearly showed the intertwining of the concepts of compound and simple interest, a key characteristic of RME (Widjaja & Heck, 2003). The Mathematics education experts found this appropriate and necessary:

*I like this very much. By including this comparison of concepts you can see wow, it's quicker to use the compound interest formula, and yet you still get the same answer as when repeating the simple interest formula.*

The experts also suggested that the app be extended to other content areas and that it be made available to a wider range of teachers.

When designing the app, the principles and characteristics of RME played an essential role. As was discussed in detail in Chapter Three, the five characteristics of RME are: i) the use of contextual problems; ii) the use of models; iii) the use of student contribution; iv) interactivity (between pupil and between pupils and teacher); and v) intertwining of learning strands.

The context was selected so that it was meaningful and natural to the students. As is illustrated in Figure 5.4, in the app in the section on the content, the scenario of a school girl or boy who wants to buy a bicycle to attend sport practice was used as it is a common and natural phenomenon to school children.
The context should allow students to develop intuitive notions that form the foundation of the concept (Stols, 2012). The authentic purchase option for the bicycle allows the students to establish and expand on the concept of Financial Mathematics. As Widjaja and Heck (2003) state (§ 3.3.2), the context should be the anchor for the formation and development of concepts. As Figure 5.5 illustrates, from the given context, the concepts of simple interest and compound interest develop in a natural manner.

![Figure 5.5: Simple Interest and Compound Interest Develop in a Natural Manner](image)

The use of models is encouraged in RME (§ 3.3.2). Models in the form of equations (Figure 5.6) are used in this task and students are also asked to model an answer when comparing the three options for the loan. They are encouraged to use any type of model and are then given information to establish if their model contains the correct information.
The third characteristic of RME is that student contributions are encouraged. Technology assists in creating an environment in which learners can be actively involved, where they can discover, explore and visualise (Stols, 2012) (§ 3.4.2).

Figure 5.7 illustrates that the app is designed with a strong emphasis on student contribution. Students are expected to enter their own values, do their own calculations and are then evaluated on...
whether the solutions are correct or not. Figure 5.8 illustrates that guidance is given to redirect them if their solutions are incorrect, but otherwise they have the freedom to work on their own.

Since this app is used by teacher-students who are situated at various rural and urban areas in South Africa, interactivity is a challenging aspect to incorporate. During the activity in the app, teacher-students are given a task that requires of them to give advice as to the most economical option between buying a television for cash or on hire-purchase. After having an opportunity to model a solution and offer the most economical option, if their answer is incorrect, they are recommended to discuss these mathematical issues with a colleague. The screenshot on the left in Figure 5.9 illustrates this example. The screenshot on the right of Figure 5.9 indicates a situation where the answer was correctly calculated, but the teacher-students are given an opportunity to discuss possible reasons as to why that answer was correct.
These examples allow for communication and collaboration with peers about the content presented in the app and activity. By discussing problem areas, it forces the teacher-students to reflect on the content, also a key principle of RME discussed by Widjaja and Heck (2003) in § 3.3.2. The aim of the app is to guide teacher-students on the implementation of the RME approach in their teaching. In a classroom situation the teacher-students will more easily be able to implement interactivity between themselves and the learners as well as between learners themselves.

The intertwining of learning strands is an essential part of RME. In this app, two types of integration have taken place. Firstly the content is integrated with a problem in the real world (Widjaja & Heck, 2003). Secondly the integration of the two concepts presented in the app is done by asking the teacher-students to calculate the compound interest option using the familiar formula for simple interest. This is illustrated in Figure 5.10. In so doing, the concepts are then presented alongside each other and the links and similarities, as well as the differences are highlighted.
A further area of connectivity is the link between the Financial Mathematics concepts and basic order in which operations are dealt with in Mathematics. In order to do correct calculations with the formulas, operations must be performed in the correct order to achieve the correct results.

Horizontal and vertical mathematization play an essential role in RME as is presented in § 3.3.3.2 with reference to the work of Treffers (1978) and Freudenthal (1991). In horizontal mathematization the student converts the problem situation into some form of Mathematics (Freudenthal, 1991). In the app, when teacher-students think about what formula to use, and what values to substitute, this conversion takes place. Vertical mathematization involves a higher level of abstraction within Mathematics, e.g. finding shortcuts and making connections between concepts (Freudenthal, 1991). Both these aspects are encouraged when teacher-students are asked to initially calculate the compound interest using repetition of the simple interest formula, and then compare that answer to the calculation done with the compound interest formula.

The process as suggested by Cahyono (2012) (§ 3.3.3.6) starts with a problem in the real world (the child wants to buy a bicycle to attend sport practice in the afternoons). The student will mathematize, reflect on the problem, do formalization (by using formulas and making comparisons) and then return to the real world (by solving the problem of which is the most economical option).

The principles of RME are discussed in detail in § 3.3.4 and include the following aspects: guided reinvention (otherwise known as progressive mathematization); emergent modelling and didactical phenomenology. These principles should be used in the design of tasks within the RME approach.
As suggested above, teacher-students are given the opportunity to develop their own Mathematics by inventing their own strategies to solve the problem. Should their strategy be incorrect, the app is designed in such a way that there is help if they require it, as can be seen in Figure 5.11. If they do not need help, they have freedom to solve the problem in their own way (Figure 5.11).

This assistance is in line with the work of Drijvers et al. (2013) (§ 3.3.4.1) who suggests that the process requires guidance from the teacher to help direct the progression in a sensible manner.

Guided reinvention was touched upon in the discussion above about vertical and horizontal mathematization. Formal Mathematics develops out of the students' activities (Gravemeijer, 1999). The context plays an important role in the reinvention process. Students are not expected to reinvent everything themselves (Gravemeijer & Doorman, 1999) and it is essential that the teacher facilitates the teacher-students through the process. The hints and guidance in the app act as a means for me as the “teacher” to facilitate their progress. In Figure 5.12, I have illustrated two different hints that are available. The first screen indicates that certain terminology has been highlighted in the app. When teacher-students click on the bold words or terms, a definition or explanation of what the term means appears on the screen. The second screen illustrates a hint that appears when an incorrect calculation is made. The teacher-students are given guidance as to how the correct value can be calculated. As I mentioned in § 3.4.2, by providing hints and tips, teachers construct a trial and error approach which allows students to use different strategies to solve problems (Heck et al., 2008).
Figure 5.12: Hints relating to the Terminology and Calculations can be Accessed

In certain instances like in Figure 5.13 they are given three opportunities to make their own attempt at a problem, and only after three attempts, will there be any intervention in the form of a hint. This allows the teacher-students the opportunity to develop and try their own strategies first, before any intervention is offered, which is a key principle in RME.

Figure 5.13: Three Opportunities are offered for Students’ own Strategies
As Dolk et al. (2002) suggests, when training teachers, it is important that they experience mathematization and reinvention first handed when learning about the reinvention process. This was an important motivation for designing the app for teacher-students to use in order for them to learn about the RME approach and implement it in their classrooms.

In the discussion on guided reinvention in § 3.3.4.1, Drijvers (2013) points out that although ICT provides opportunities for reinvention, it may constrain students’ prospects for exploration as a result of too much pre-planned guidance. I kept this in mind when designing the app and hence incorporated the prompts that first ask if the student needs help, rather than just offering the help, also allowing them three opportunities to offer a solution before any remediation or hints are given.

The second principle of RME is emergent modelling, which refers to the idea that models emerge from the activity of the students (Gravemeijer, 1999). The use of models is also discussed above as one of the characteristics of RME. An important aspect is that activities should be designed in such a way that students can shift from reasoning with models of informal activities to modelling of formal Mathematics (Bakker et al., 2003). I have tried to incorporate the modelling of informal activities through the use of the simple and compound interest formulas. In the activity, when teacher-students are asked to model an answer that would be the most economical purchase of a television, they have the opportunity to model the formal Mathematics. As discussed in § 3.3.4.2, models should be grounded in the context problems and not in intended Mathematics (Gravemeijer, 1999). In the app, the purpose of creating the model is to solve the problem in the given context, for example to give advice on which of the three options is the most economical when buying the bicycle, and also which option is the best when buying a television. The context demands the creation of the model, not the Mathematics.

The third principle of RME as was discussed in § 3.3.4.3 is didactical phenomenology. Meaningful phenomena that need to be structured and organised are presented to students and should be organised by the Mathematics (Drijvers, 2013). The phenomena of a person's personal finances, is the focus of the app. The scenario of buying a bicycle, and the choices offered when buying a television needs to be organised and structured with the aid of the mathematical content.

With reference to the aspects that should be considered in the design of Mathematics apps as suggested by Cayton-Hodges et al. (2015, p. 16) in § 5.3.2, I incorporated the following four aspects in the design process. Firstly, a rich and accurate representation of the mathematical content should be done. In the app I provided users with definitions of terms such as hire-purchase, simple interest, compound interest, the meaning of p.a.; I gave assistance with necessary simple and compound interest formulas and also made connections between different strands to reinforce the content. The second aspect discussed in § 5.3.2 was that the interactions around the content should be lavish and engaging. I provided numerous opportunities for the user to interact with the content at various levels.
I ensured that the user is constantly engaged by providing cues and links between screens and activities. When calculating the compound interest using the simple interest formula, I involve the users by saying the following: Correct! What about the second year? Now enter the values to calculate the loan for the second year. This is illustrated in Figure 5.14.

![Figure 5.14: An Illustration of How Users are Encouraged to Engage with the Content](image)

The third aspect discussed by Cayton-Hodges et al. (2015, p. 16) is that users should be given the opportunity to reflect on tasks. This aspect has also been incorporated in the Financial Mathematics app. In Figure 5.10, I encourage users to reflect on why two answers are the same and recommend that they discuss possibilities with a friend or colleague. Another example of this can be seen in the screenshot on the right of Figure 5.12, where users are again encouraged to reflect on a particular answer. The fourth aspect discussed in § 5.3.2 is that hints, scaffolds and other tools are important in the design of apps and that these should be presented on a need to know basis. Figure 5.11 and 5.12 both illustrate examples of hints and assistance that are available to the user, should they require these. The manner in which the app was structured and designed is evident of a process of scaffolding. Small portions of information and tasks are given one step at a time so that users can be guided through the process of learning the content and doing the activities.

### 5.5.2 The Technical Aspects of Creating the App

When creating the app, the design team followed nine distinct steps. Firstly, a clearly defined purpose of the mobile app was defined. This entailed a detailed exploration of what the app should be able to do; what its primary appeal would be; which concrete problem it would address; what aspect of life it
aimed to improve. I designed, re-evaluated and refined the design documents which sketched the standards, planning design, development and on-going evaluation of the project (Alessi & Trollip, 2001). The second step set the basis for the user interface. This entailed a visual conceptualisation of the main features as well as a rough layout and structure of the app. The designer created sketches of the proposed layout and structure of the app. Step three involved a search to establish if there were other similar apps available. This was necessary because there are over one million apps for Android and iOS already available. This search also assisted the designer with design inspiration for the Financial Mathematics app, and provided him with information on the technical requirements for the app. The designer downloaded three free analogous apps from the Google Play Store and studied their look and feel, and where applicable noted aspects that could be appropriate for the Financial Mathematics app.

In the fourth step, all the ideas and features came together as a clear picture of the prototype of the app. This process is known as wire framing (Lloyd & Dykes, 2011, p. 2501) and also entails the creation of a storyboard for the project. The storyboard provided a road map which illustrated the connections between the different screens and also how the user could navigate through the app. The result of the fourth step, the prototype and the storyboard, became the basis of the back-end structure for the fifth step. This step involved the sketching of the servers, app programming interface (APIs), and data diagrams as helpful references to the designer. These sketches provided self-explanatory diagrams that all could follow during the project. Step five also included modifications to the prototype and storyboard according to technical limitations. Because of the limited size of the app, no additional modifications to the prototype and storyboard were necessary.

The sixth step was an essential one. Friends, family, colleagues and experts were approached to review the prototype. They were requested to test the app and give feedback and identify flaws and dead-end links. Based on this feedback, the app was modified. This review step was done to finally specify the app concept before going into the design process. At this point I tested the app with the RME expert and two colleagues, who are Mathematics education experts (§ 5.5.1).

In step seven, individual screens were designed. The task was to create high-resolution versions of the prototype. Here, the designer included all comments from the prototype testers, so that the optimal user interface could be designed. Upon completion and implementation of the individual screens, the actual app concept was complete. All the graphics were inserted and I signed off on all text. The actual design was now implemented and made clickable. Step eight was to test the full design again and collect as much feedback from a variety of users. These new ideas and suggestions were used to refine the app. The designer effected the last changes to the layout.

The final step ensured that there was a consistent look and feel to the layout, and that it would perform reliably on different devices. The Financial Mathematics app was installed on various android devices.
and was tested for functionality in a live environment. The final completed product was uploaded to Google Play Store and made available for the teacher-students to utilise and examine further.

Figure 5.15: Illustration of the App in Google Play Store

Figure 5.15 illustrates the app which is available for free in Google Play Store. The app in question is the second from the top in the illustration. The next phase of this process was to present the completed app to the teacher-students in order to establish their experiences, perceptions and feedback regarding the app.

The nine steps that the design team followed in designing the Financial Mathematics app are loosely based on the framework that Lee and Kautz (2015, p. 577) suggest for the design and implementation of mathematical tasks in mLearning environments (§ 5.3.2).

Table 5.1: Comparison of the steps used in designing the Financial Mathematics app with the Design Framework of Lee and Kautz (2015, p. 577)

<table>
<thead>
<tr>
<th>Design and implementation framework as suggested by Lee and Kautz (2015, p. 577)</th>
<th>Design and implementation steps of the Financial Mathematics app</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define Lesson Objective</td>
<td>1. A clearly defined purpose for the app was designed.</td>
</tr>
<tr>
<td>Define technological environment</td>
<td>2. A visual conceptualisation of the main features as well as a rough layout and structure of the app was designed.</td>
</tr>
<tr>
<td>Define types of investigations</td>
<td>3. A search was done to establish if there were other similar apps available.</td>
</tr>
<tr>
<td>Design and develop task(s)</td>
<td>4. Wire framing and the creation of a storyboard for the project.</td>
</tr>
<tr>
<td>Design and develop task(s)</td>
<td>5. The servers, app programming interface (APIs), and data diagrams were sketched. Modifications to the prototype and storyboard were done.</td>
</tr>
</tbody>
</table>
Design and implementation framework as suggested by Lee and Kautz (2015, p. 577) | Design and implementation steps of the Financial Mathematics app
---|---
6. The review of the prototype by various parties.  
7. Individual screens were designed. 

Implementation | 8. Testing of the full design again. As much feedback as possible from a variety of users was collected.  
9. Ensuring a consistent look and feel of the layout, and that the app would perform reliably on different devices. 

Enactment | The app was presented to the teacher-students for their feedback and perceptions. 

Table 5.1 illustrates how the steps that were followed in the design process for this study was based on the design framework of (Lee & Kautz, 2015, p. 577).

The paper entitled Design of a prototype Mobile Application to make mathematics education more realistic written by the programmer, myself and my promoter underwent a peer review process and has been accepted for the proceedings of the 13th International Conference of Mobile Learning in Budapest from 10 -12 April 2017. The paper is available at Addendum 5.2.

### 5.6 Chapter Summary

This chapter presented a discussion of why a mobile app was suitable for this study and went on to sketch the background of what mLearning is. The associations between the use of technology and the RME approach were also presented. The chapter further explored the context of the teacher-students for which the app was designed. A detailed discussion of the process that was employed to design and test the app followed. In this discussion the theoretical aspects of the design were discussed: the various phases of design were discussed; the creation of the different prototypes was explored as well as the testing of the app; how the design of the app was related to the principles and characteristics of RME; as well as the technical aspects that were followed to design the app. In Chapter Six, the data generated from the focus group interviews were analysed. Teacher-students were introduced to the app and their evaluation and perceptions of the app were analysed in the following chapter.

As was discussed in § 2.4, throughout each stage of a design-based research project, researchers will reflect and document aspects to produce scientific output in the form of theories or design principles (Plomp, 2007, p. 15). As is illustrated in Figure 2.6, upon completion of the design, development and formative evaluation phase, I have produced a number of design principles relating to that design phase. The design process led to the awareness of a number of principles that were followed in the design process. These principles are presented in Table 5.2.
Table 5.2 Design Principles for the Design of a Mobile App Based on the Principles of RME Derived from the Design Process

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thorough planning of the app</td>
<td>• A detailed design document should be created</td>
</tr>
<tr>
<td></td>
<td>• The problem situation should be clearly sketched</td>
</tr>
<tr>
<td></td>
<td>• The purpose of the app must be clearly defined from the start</td>
</tr>
<tr>
<td>Rigorous testing of the app throughout the design process</td>
<td>• The different prototypes should be rigorously tested by a range of parties (novices and experts)</td>
</tr>
<tr>
<td>The principles and characteristics of RME should be included</td>
<td>• The intertwining of concepts and strands should be incorporated</td>
</tr>
<tr>
<td></td>
<td>• Relevant contextual problems must be used</td>
</tr>
<tr>
<td></td>
<td>• The use of models ought to be encouraged</td>
</tr>
<tr>
<td></td>
<td>• User interaction with the app and contributions should be encouraged</td>
</tr>
<tr>
<td></td>
<td>• Users ought to be given the opportunity to invent their own strategies to solve problems</td>
</tr>
<tr>
<td>Pedagogical Aspects</td>
<td>• Mathematics content should be rich and accurately presented</td>
</tr>
<tr>
<td></td>
<td>• Interactions with the content should be engaging</td>
</tr>
<tr>
<td></td>
<td>• Users must be given the opportunity to reflect on tasks</td>
</tr>
<tr>
<td></td>
<td>• Hints and scaffolds should be incorporated and used on request</td>
</tr>
</tbody>
</table>
Chapter Six
Participants’ Observations and Experiences of the Mobile App

6.1 Introduction

In this chapter I report on the analysis of the data obtained from the focus group interviews. Ultimately I aim to produce guidelines for the effective use of technology in implementing the principles of RME in teaching practice. In order to create these guidelines, I need to establish how the participants’ experienced using the app and what observations they made about the app. After having gained insight into the existing literature regarding the use of the RME approach assisted by technology in Mathematics education in the systematic literature review (Chapter Three) as well as by establishing the needs expressed by the participants in terms of applying the principles of this approach in their teaching (Chapter Four), I, together with a design team, designed a mobile app for the topic of Financial Mathematics. In the design of this app I took into account all aspects previously explored in the existing literature and needs analysis of the participants to create a suitable and rewarding intervention tool that could aid the participants of this study as well as other teacher-students in future to make their teaching of Mathematics more realistic.

The next stage of this study was to effectively produce the required guidelines that would answer the third research question: *What are the guidelines for the effective use of technology in implementing the RME approach in teaching practice?* In order to proceed to this stage, it was necessary for me to again meet with participants and present them with the completed app. Then I had to establish how they experienced that app, determine their observations about the app and take note of any critique they had to offer about the app. The plan to gain this information was to arrange a focus group interview with all four participants. However, it was not possible for one of the participants to meet with the other participants due to logistical reasons. I therefore decided to divide the group in two and have two focus group interviews. In each focus group interview, there were two participants and myself, who acted as the interviewer. I designed an interview schedule (Addendum 2.8) which was loosely based on the main themes of the systematic literature review. The focus group interviews took place in my office at the Potchefstroom Campus of the North-West University. I paid for the travel expenses of each student and provided them with refreshments to ensure that they were comfortable and that I did not cause them any inconvenience. These meetings took place outside of school hours, and did not disrupt the participants’ teaching programme in any way.

I transcribed the recordings of the focus group interviews with the aid of ATLAS.ti™ (ATLAS.ti, 2014). As with the individual interviews, data were again coded in the same HU as the systematic literature review in ATLAS.ti™. I therefore used the existing codes and created three additional codes in order to code and categorise the focus group interviews as part of an integrated HU. The detailed
codebook was discussed in Table 2.6 (§ 2.6.5). I extended the codebook with three additional codes, which are presented in Table 6.1.

Table 6.1 Extension of the Codebook Table

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability of the app</td>
<td>Any comments made by the participants regarding the usefulness and ease of use of the app.</td>
<td>&quot;The app helps to make the lesson more interesting&quot; (P62:51).</td>
</tr>
<tr>
<td>Positive aspects of app</td>
<td>Any positive aspect that the participants raised in relation to the design, implementation or usability of the app.</td>
<td>&quot;It is also going to motivate the ones who didn’t get the correct solution&quot; (P65:7).</td>
</tr>
<tr>
<td>Suggestions to improve app</td>
<td>Any suggestions that the participants had with regard to improving the app in relation to content or technical aspects.</td>
<td>&quot;Maybe you consider specific topics for the slower learners, for those who are willing to learn you can give them more advanced content&quot; (P65:22).</td>
</tr>
</tbody>
</table>

As with the individual interview data, the five themes that the systematic literature review revealed also formed the foundation of the structure for the analysis of the focus group interviews. As in Chapter Four, the four main themes used in this chapter were: Mathematics, RME, ICT and role players. I refined the themes further to suit the focus group interview data as: observations of the app in terms of Mathematics; the facets of RME observed in the app; considerations and ideas about ICT; and role players in the given context. Since the focus group interviews also focused on the evaluation of the app, I added the following theme: suggestions relating to the app. Figure 6.1 depicts the network view of the coding structure and themes that were used in the data set.

![Diagram](image_url)  

**Figure 6.1: The Coding Structure for the Needs Analysis Individual Interviews**

The themes as discussed above and a more refined structure for the analysis that follows in this chapter are presented in Figure 6.2.
Figure 6.2: Advance Organiser of the Main Themes for the Analysis
6.2 Observations of the App in terms of Mathematics

There were five sub-themes that materialized within this theme, namely factors that influence teaching and learning; Mathematics content; learner aspects; teaching methods and strategies; and meaningful learning of Mathematics. Figure 6.3 displays the categories for the observations that the participants made in terms of Mathematics.

6.2.1 Factors that Influence Teaching and Learning

As discussed in § 4.2.1, immediate feedback is not only an essential aspect of effective teaching and learning, but was also an aspect that the participants found to be important for their learners. The participants reported that the app provided immediate feedback to the user:

> And also the feedback—they will get immediate feedback. In the end it will help them to correct their sums. If they are getting it wrong, it will tell them—this is wrong. This is going to help the teacher in the class—getting feedback immediately. Even time is not going to be wasted (P65:19-20).

> I think it is good. I also think that it is going to challenge the users. Especially the part where they can choose if they want help or not. Most of them will choose the no—they do not ask for help. But if they get it wrong, they will get feedback immediately from the app. Those slower ones will go for the yes. As time goes on, they will improve and will opt for the no. And then they will keep on improving (P65:2).

In the systematic literature review (§ 3.2.1), it was also established that motivation can increase due to three factors: digital assignments; diagnostic testing; and the use of real life contexts. This was confirmed by the participants who said that:

> The teachers and learners will be motivated to use this app (P62:22).

> There will be those that are so motivated by the app that they will just improve (P62:54).

> The first ones who have done a solution and find the solution to be correct, they will boast to the others who did not find a solution (P65:6).

---

2 “No” refers to clickable icons in the app where users are given the option to get help with formulas, values and methods or not. When users click on “No” it indicates that they do not need help. When they click on “Yes” it indicates that they do want help. In this case help is provided.
It will help them (P62:38).

They will love it! (P62:23).

When asked how they would use the app to improve teaching practice, the response was:

At any time when they feel like using it, while revising they can just use it (P62:37).

Those who are lazy to write and those whose handwriting is horrible—the app can help—it cuts all of that out (P62:52).

Those brighter ones will go for the no, they will want to do it for themselves. The slower learners will go for the yes, for the help. As time goes on they will also want to go for the no. So you are catering for both (P65:4).

It will also help those who battle to read. It will also improve their reading skills if they can hear and see at the same time (P65:41).

As discussed in § 3.2.1, technology allows learners to work creatively (Zaranis et al., 2013) and, when used correctly, improves problem solving skills and promotes critical thinking (Stols, 2012).

### 6.2.2 Mathematical Content

One of the participants raised an important issue in Mathematics education and that is mathematical content knowledge:

Based on the needs for the content, we must acquaint ourselves first with the content before we can use it here (P62:18).

Content knowledge is an essential component of what Ball et al. (2008, p. 395) refer to as mathematical knowledge for teaching (MKT). They define this as the “mathematical knowledge needed to carry out the work of teaching mathematics.” Of relevance in this study as well is the incorporation of the teacher-students’ knowledge of technology, as described by Mishra and Koehler (2006) in the TPACK framework (§ 1.3.1).

Further to the discussion on mathematical content, I asked the participants which sections of the curriculum they thought might benefit the most from an app such as this one. Their responses were: Calculus, Financial Maths, Probability, Geometry (specific mention was made of the theorem of Pythagoras), data handling, and graphs. The participants summarised it as follows:

The only one that will suffer will be Algebra. But the rest, even number patterns will be fine (P62:39).

Any section would be suitable (P65:35).

### 6.2.3 Learner Aspects

The theory of RME revolves around the construction of knowledge (Gravemeijer, 1999). Teachers should be sensitive to where their learners are (§ 3.2.7) and should design activities accordingly to provide them with the opportunity of constructing knowledge (Kizito, 2012a). Participants shared their ideas on how the app can meet the varying needs of different learners in the Mathematics classroom:

The weaker learners can be able to do it. If they can’t then they click on the icon for help. It helps the weaker learners (P62:13).
There are learners who are so shy when they are in class they can work comfortably when they are alone. I think this will be so helpful especially for the weaker learners (P62:14).

A more advanced learner can do even more work. A slow learner you can give them more time (P65:21).

In this way you can attend to individual learners (P62:2).

The demotivated learners will also be motivated (P62:25).

It is also going to motivate the ones who didn’t get the correct solution and even improve the pace at which they work (P65:7).

6.2.4 Teaching Methods and Strategies

Models come in many forms and are more than a visual representation of abstract Mathematics (Boon, 2006) (§ 3.2.5.1). Modelling ideas can be done in the form of words, diagrams and formulas (Muthen & Khoo, 1998). Participants discussed challenges they experienced with their learners with regard to the use of formulas:

So, you can even ask for the formula. Because sometimes they struggle to know which formula they should use (P62:3).

6.2.5 Meaningful Learning of Mathematics

As discussed in § 3.2.5.2, the RME approach can contribute towards a positive classroom climate (Fauzan et al., 2013). Participants mentioned the possibility of healthy competition between users when working with the app:

In fact there will be a competition (P65:5).

This endorses what was discussed in § 3.2.4 which says that one way in which meaningful learning can be encouraged is through playing games (Zaranis et al., 2013). Another participant said the following:

They like technology. They like to use cell phones. It’s like playing games—they like playing games, wherever they are they play games. This is like playing a game (P62:25).

Participants suggested ways in which the app could contribute in their teaching:

My school has tablets and in my grade twelve Maths classes there are only twenty one learners, I am going to download the app to help them. What I like most is that the users can work on the Maths at home (P62:49).

This app can help with very large classes (P62:50).

When asked how this app can assist teachers to teach Mathematics in a meaningful way, the response was:

It can. It can. As a teacher...because each and every teacher wants their learners to be involved. You can get them involved if they have got this. You can communicate with them through this (P62:12).
6.3 Facets of Realistic Mathematics Education Observed in the Mobile App

The characteristics, principles and aspects of RME have featured strongly throughout this study. In the focus group interviews, participants also divulged their ideas on which facets of RME were apparent in the app. This theme was discussion with the sub-themes of characteristics and aspects of RME. Figure 6.4 illustrates the coding structure for this discussion.

Figure 6.4: Coding Structure for the Facets of Realistic Mathematics Education Observed in the Mobile App

6.3.1 Characteristics of Realistic Mathematics Education

In § 3.3.2, I discussed the characteristics of RME in detail. These included: the use of contextual problems; the use of models; the use of student contribution; interactivity and intertwining of learning strands (Drijvers & Doorman, 1996). One of the questions in the focus group interview schedule was: How does this app address the principles and characteristics of RME? The participants shared their views of the characteristics of RME that they noticed in the app:

- The topics are intertwined. They can bring topics together. They can see how this one is intertwined with the next topic (P62:11).
- And they are actively involved (P62:11).
- There will be collaboration, when they are together. They will ask each other: Who has done the sum first? (P65:17).
- I think all the characteristics of RME are there. There is collaboration; users will be actively involved for sure—they are doing it themselves. Intertwining of strands is there: like with simple and compound interest—showing that you can use simple interest to get to the compound interest formula (P65:18).

6.3.2 Aspects of Realistic Mathematics Education

The emphasis on real life situations has been discussed throughout this study (Gravemeijer & Doorman, 1999). When evaluating the app, the participants also noted the link to real life:

- You can do Maths with something that they know—make it real life (P65:46).

The second aspect of RME that forms one of the cornerstones of the approach is that Mathematics is a human activity (Freudenthal, 1971). This aspect was discussed in detail in § 3.3.3.1. Participants shared their ideas on this aspect:

- Anywhere, in a taxi, in a bus—wherever they are, they can do Maths (P65:10).
6.4 Participants’ Observations and Experiences of Information and Communication Technology in the Mobile App

In this section I will discuss the participants’ observations and experiences of ICT in the mobile app. The five main themes are the same as those discussed in Chapter Four. These include: the value of ICT; challenges when working with ICT; the use of various devices; technology used as an educational tool; and factors of ICT that relate to the participants. Figure 6.5 illustrates the network view of the coding structure for the participants’ observations and experiences of ICT in the app.

![Figure 6.5: Coding Structure for the Participants’ Observations and Experiences of Information and Communication Technology in the Mobile App](image)

6.4.1 The Value of Using Information and Communication Technology

The systematic literature review detailed the value of using ICT in education (§ 3.4.1). More specifically, the benefits of mobile technology were discussed in § 5.3.1. Progressively more educators are using mobile technology for increased learner engagement; interaction and collaboration among peers; and as an extended time and place for learning (Kiger, Herro, & Prunty, 2012, p. 62). Participants also identified the value of using the app on a mobile device:

Because it gives the user a chance to do Mathematics anywhere, anytime. They will get immediate feedback (P65:9).

Rather than going home, having to take out books and then learning—it can be done anywhere at any time (P65:10).

They can afford to buy cell phones rather than computers. Even though that can’t afford to buy computers they can buy cell phones (P62:8).

It’s more accessible to them and it’s easy to carry, where they are and while they are relaxing they can learn while you are sitting outside (P62:9).

6.4.2 Challenges while Working with Information and Communication Technology

Technology has proved to be a suitable way to facilitate RME in teaching Mathematics (§ 3.4.5), however, there are challenges when integrating ICT with the principles of RME (Drijvers et al., 2013). One of the recommendation in the work of Kizito (2012a) was that future studies should make use of
interviews to explore students’ perceptions of mobile technology (§ 3.4.6). Participants in the current study were given the opportunity to express their views on mobile technology in two separate interviews. They discussed challenges they perceived when working with the mobile app:

It's a challenge for some teachers. The teachers must know how to download it. Without downloading it, I will be stuck (P62:16-17).

To manage time can be a problem. If the users are used to doing Maths on the technology and they now have to write it out they will not know how much time they should spend on each question (P62:53).

I think it would limit their basic skills—those learners will not have the basic Mathematics skill like calculating. When it comes to exam time, they will not be able to use this. They will use paper-and-pencil. If they are used to the technology—it can be a problem for them to write exams with paper-and-pencil (P65:48).

I don't think they should only use this—in the end they should also write something. So, one should create opportunities for them to answer questions on paper-and-pencil as well—after learning the content, maybe use worksheets where they get to do the sums on paper (P65:49).

In the last quotation above, participants expressed the concern of becoming too reliant on the app, and that written activities should also be incorporated into a lesson. This issue was also raised in § 3.4.6 where Zaranis (2014b) warns against tool dependency.

6.4.3 Devices

Various aspects of mLearning in Mathematics were discussed in § 5.3.2. One important aspect is that mLearning creates new opportunities for learning in Mathematics (Graven, 2011, p. 45). Participants mentioned their observations about various devices, particularly mobile devices in their contexts:

This generation like using these devices. They are interested in using cell phone, tablets. It will capture their minds. So they are focused, they will be focused (P65:34).

Cell phones, there are many. Let's say more than 90% of them they have cell phones (P62:7).

6.4.4 Technology as an Educational Tool

Mobile technologies such as the mobile phone and tablet computer have the potential to profoundly change how teaching and learning is conducted (Petocz & Manuguerra, 2011, p. 61). Mobile technology serves as an ideal means in which to facilitate change with regard to a new generation of students and their new ways of learning, yet offering the same content in new formats (Petocz & Manuguerra, 2011, p. 65). The participants in this study also saw the potential of mobile technology in teaching Mathematics:

They can teach themselves with this, while they are revising and doing this, they can check on themselves. Because the learners will be directly involved. They won't sit back and just listen to you saying everything. They will just type it in, rectify themselves. They are actively involved, and they can interact with others (P62:5-6).
6.4.5 Participants’ Information and Communication Technology factors

In the individual interviews, participants in general expressed their positive attitude towards working with technology in the Mathematics classroom. This stance was extended to the focus group interviews as well. Here it was also apparent that they felt that the Financial Mathematics app could aid the teaching process, and that users of the app would not have difficulty in navigating and using the technology:

*I don’t think the technology will hinder them. Let’s take for example, all the Maths educators can use a calculator—so I don’t think it will give them a problem. They will get used to smart phones. As long as they get used to using a calculator, they will get used to using the smart phone. Those educators that are not Maths educators, they struggle to work with a calculator (P65:24).*

*If they can be showed how that is working, it won’t be a problem. Even the calculators—how to use the calculator—we were never taught how to use a calculator, but in the end we know how to use the calculator. There are topics that we have to use a calculator, so we were never taught how to use a calculator (P65:25).*

*It wasn’t a problem to navigate. The fact is we own cell phones and we have been fiddling with the app. To work on this technology, is easy. But for a person who has got this for the first time it will be a challenge. Based on what we know about learners, most of them do have cell phones. I think they can use it (P62:15).*

The participants did mention possible challenges relating to technology use, especially for the older generation of teachers:

*It will be easier for the new teachers because they know technology. The older teachers they might struggle a bit (P62:51).*

Despite the challenges, their aspiration to move forward is again evident (§ 4.2.1):

*With the cell phone, nowadays we all have cell phones, we use cell phones and we are also encouraged to align ourselves with the current technology. So it shouldn’t be a problem (P65:26).*

In the individual interview, one participant in particular expressed his views about mobile phones, where it was apparent that he did not see them as a tool for teaching Mathematics. He said the following:

*About the cell phones, I don’t think it’s good...you can say cell phones are not designed for teaching and learning, it’s just for communication purposes, so if you use them for teaching and learning, I don’t think it’s a good idea, unless if you want to communicate with them, send them homework, maybe the results, something like that (P59:36-37).*

When I presented the app to him and we proceeded to discuss its use in the Mathematics classroom, he said the following:

*It will work. It is interesting...This is a new method of doing those things which are giving learners a problem. Nowadays people like this sort of things—they like using technology...This generation like using these devices. They are interested in using cell phone, tablets. It will capture their minds. So they are focused, they will be focused (P65:44-49).*
It was encouraging to notice a change of heart in this participant with regard to using mobile technology in the classroom. Another participant summarised his impression of the app in the following manner:

*I am very impressed. In fact we are tired of chalkboards—it will be nice to use something new (P65:50).*

### 6.5 Role Players

One question in the focus group interview was: *Which role players will influence the use of an app such as this in the school situation?* One of the participants responded in the following way:

*I think all of them play a role (P65:28).*

Figure 6.6 portrays the coding structure for the different role players in this study.

![Figure 6.6: Coding Structure for Various Role players in the given Context](image)

### 6.5.1 The Role of the Teacher

In the systematic literature review (§ 4.5), it was noted that not all stakeholders share the same optimism about using ICT in teaching and learning (Heck et al., 2007). The participants all suggested that the Mathematics teacher would be the greatest influence on the successful use of the app:

*The Mathematics teacher is directly involved with this app. They must convince the parents; they must convince the Department that they need this app. The Mathematics teacher will influence its use (P62:26-27).*

*The Mathematics teacher must encourage all the stakeholders to be involved in using the app. By showing them how possible, how easy and how economical it is to use it. But if you have no facts to support your statement then you will fail, the Department will fail to deliver this. But if there is a need and it can be shown to the stakeholders that if we apply this app—we save time, all learners are involved, all learners are interested. Maybe we should have one class where we use the traditional method and one classroom, use this technology and show the difference between them (P62:29).*

*On the part of the educator—the educator, the Mathematics educators should take the initiative to show that this really works (P65:28).*
A participant also emphasised the key role that the teacher should play in the implementation of the mobile app in the classroom:

But, a teacher is a leader—they must always be in front of the learners. Teachers must learn more. They must be able to know it first before they can take it to the learners (P62:20).

6.5.2 The Role of the Learner

A participant expressed her optimism that the learners would positively influence their parents with regard to the learners’ use of the mobile app in the Mathematics classroom:

You just show the learners first. Then we call a parents’ meeting. The learners would already have told their parents about the app. We will just show them how easy it will be (P62:28).

6.5.3 The Role of the Community

When discussing the role of the community after having done the individual interviews, various factors relating to parents were raised (§ 4.5.3). An aspect that was evident was that parental support has a significant effect on learner motivation (Wentzel, 1998, p. 206) as well as academic performance (Makgato & Mji, 2006, p. 261). In the focus group interviews, parents also featured in the discussion:

Even their parents will be motivated to buy them cell phones and then even improve to buy more smartphones and install mathematical programs on the cell phones (P65:15).

Because let’s say for example parents—in terms of the cell phones—if we can tell the parents to buy cell phones for the learners, then parents can buy it. As long as they realise that it is effectively used and can benefit the learners, they are going to buy it (P65:28).

6.5.4 The Role of the Context

School management and departmental issues featured in the focus group interviews, as they did in the individual interviews. Departmental characteristics have a definite impact on student learning (Vermunt, 2005, p. 205). Some of the aspects that are referred to as departmental characteristics include: course design and objectives, learning materials, and assessment procedures. The participants raised issues relating to departmental issues as well. Their concern was with role players such as the Heads of Department (HODs), Principals and the Department of Education:

In terms of the HODs and principals, they are the ones that should come up with the implementation and encourage the educators to implement this. So, if the Head of Department can encourage educators to implement and if the educator is prepared to implement—then from the Department to the parents—everything will run smoothly. Because the Department I think they should come up with programs where they design programs for the schools then the HOD’s and the principals should check that those programs are implemented (P65:28).

When asked if school principals would be happy for teachers to use an app such as this one, participants responded as follows:

Not at all. They like teachers to work. They think we are lazy (P62:30).

Not at all. It involves money. This involves money. If for example you go to the principal and say that you want to use this app, you will work out the feasibility—how much will it cost—it will work out to be thousands. If the principal had never seen it being applied, it will not be easy to convince them. It was for the Maths teacher to convince. That’s why I said if I bring
the principal to class and show him how wonderful this app works, then maybe he can buy
the story. Then we’ll be fine (P62:30).

I think this is a question of whether the school has money to buy the technology. If the
Department can provide the technology, then we can always use this technology. Just like
textbooks—they provide textbooks, so they can provide mobile technology, then it will be
simple (P65:27).

6.6 Specific Aspects Relating to the App

The codes that were added to the HU when coding the focus group interviews all fall into this
category. Since the emphasis of the focus group interviews was on the evaluation of the app and to
determine what observations and perceptions the participants had about the app, it was necessary to
create codes that accounted for any suggestions the participants had with regard to the app. The
sub-themes that fell into this category were: the usability of the app, positive aspects about the app
and suggestions to improve the app. The coding structure for this section is illustrated by Figure 6.7.

![Figure 6.7: Coding Structure for Specific Suggestions relating to the App]

6.6.1 Usability of the App

The usability of the app refers to the usefulness and ease of use of the app. Usability is often
measured in terms of three aspects, namely: effectiveness, efficiency and satisfaction (Harrison,
Flood, & Duce, 2013). These three aspects were all accounted for by the participants in this study.
Effectiveness is illustrated by the following comments:

- It will work. It is interesting (P65:30).
- The app helps to make the lesson more interesting (P62:51).

Efficiency is illustrated by the comments that follow:

- They can play with this and still arrive at the right answer (62:4).
- They won’t find it difficult to use this technology—they are hands on (P65:33).

Satisfaction is demonstrated by the following:

- Ah, it’s so easy! (P62:1).
- This is excellent, excellent! (P65:31).
When asked if the app was easy to navigate, the participants replied:

It was for the first time, but it was not so difficult. But once used, I’m telling you it will come easy to them (P62:36).

6.6.2 Positive aspects about the App

Two comments that the participants made related to design aspects:

The terminology helps them to differentiate between the two concepts (P65:1).

It helps by giving them three chances to do sums (P65:3).

The other observations were made concerning more general aspects:

This is a new method of doing those things which are giving learners a problem. Nowadays people like this sort of things—they like using technology (P65:32).

I think this will help in other subject too—if teachers that teach other subjects can see this, they would also want to use such apps. This will help them too (P65:47).

6.6.3 Suggestions to Improve the App

The suggestions offered by the participants in terms of improving the app can be divided into three categories. These categories are suggestions relating to pedagogical aspects; design aspects and general additional aspects to consider. Regarding pedagogical issues, participants suggested a greater variety of questions for two reasons: firstly to cater for slower learners and secondly to ensure the whole coverage of the curriculum.

Maybe you consider specific topics for the slower learners, for those who are willing to learn you can give them more advanced content (P65:22).

I think putting all the questions that could be available—so that you can attempt each and every question that is possible. Otherwise if the question is not there and they are applying this—there will be a challenge, even if I don’t know how to do it now. They will be a challenge; I can contact whoever to help me. So to improve it, let’s have as many questions as possible, especially those in real life. Having all the questions will give an opportunity for interaction with other learners and with the teacher. Once they are loaded it will put a challenge to the user each and every time they open the phone. I think it can be improved in that way (P62:41).

In § 5.5.1, I have illustrated how I made use of hints and scaffolds, which is encouraged by Cayton-Hodges et al. (2015) in the design of mobile Mathematics apps. Participants were reluctant to immediately offer such hints and would prefer that users have plenty of opportunity to try on their own before any such scaffolding takes place:

Like we already said, just to change where the learners have to choose between yes or no. They should be given more opportunity to do it on their own first. They should be forced to try the sums on their own first, and then the help can come. Twice or thrice is enough otherwise they might become demotivated (P65:36).

Block it and then they can’t access it anymore. Then they know they must try themselves. They must be able to think (P62:44).

Concerning the issue of design, interactivity was an essential component that was taken into account in the app for two specific reasons. Firstly, interactivity is an essential characteristic of RME (Zulkardi,
Although some interactivity was built in to the app, the participants were keen to increase the levels of interactivity:

Secondly, I would say how can I show this to someone else—how can this be shown to a colleague, while I am working, so that other colleagues can help me (P62:41).

They should be able to contact fellow users, like with WhatsApp™. I can say how do you do this? I couldn't get to the right answer, how do I tackle it? They can look into your steps and say no, you are using the wrong formula. Let's try this formula. By a friend, the learners feel so proud when they can help a fellow learner (P62:42).

The final aspect to be discussed is the additional aspects that might be considered for inclusion in the app. Apps have the potential to offer affective engagement. This type of engagement is often influenced by the visual and interactive characteristics of the app (Calder, 2015, p. 245). This is a shortcoming that the design team also identified in the design of the Financial Mathematics app. Participants pointed out the following:

I think if you can make it to be audio-visual - that would be great (P65:37).

There was also no sound. The sound can tell them what to do. Maybe make it an option for learners—those who want sound maybe have that option, those who don't want sound can switch it off (P65:38-39).

I have seen that you have put some colourful pictures in there—even in the formula—maybe add some pictures but not too much. It should also depend on the grades—maybe in the senior and FET phases you can limit the images. In the lower grade you can include more pictures (P65:42-43).

What about animation? It will be good especially for the grade fours, fives and sixes—because they like cartoons—you can add it there. If you can include animations that will be good for the lower grades (P65:44).

A general comment which is encouraging for future development was:

It would be good if you could develop these apps for the whole curriculum—from foundation phase right through. Then they can get used to using it (P65:45).

6.7 Chapter Summary

In this chapter, I presented a detailed analysis of the data that were generated at two focus group interviews with four participants in this study. The aim of the focus group interviews was to establish the participants’ observations, opinions and experiences of the mobile app for Financial Mathematics. A number of familiar themes were apparent in this data. I firstly explored the participants’ observations and experiences of the app in terms of Mathematics. I dealt with various factors that influenced the teaching and learning of Mathematics. The aspects that arose in this section were the importance of immediate feedback in the app; and the opportunity for increased motivation that mobile technology offers its users. Participants also offered various reasons as to why they felt that the mobile app could improve their teaching practice. In this category, I also explored the participants’ ideas on mathematical content. Two important aspects transpired. Firstly participants discussed the importance of mathematical content knowledge, and secondly they revealed other sections of the curriculum that would possibly benefit from the design of similar apps. The third aspect of this section
addressed learner aspects. Participants discussed how the app met the varying needs of different learners. Concerning teaching methods and strategies, I discussed the modelling of formulas as an important teaching method. Finally, I discussed aspects relating to the meaningful learning of Mathematics. Features that were discussed included the notion of competition and games that the app evoked in the participants, and the importance thereof in contributing towards an environment in which meaningful learning could take place.

The second theme that I explored was that of RME. The facets of RME that the participants observed in the app were characterised into two components: characteristics of RME and aspects of RME. The participants were able to identify all the characteristics of RME, in particular collaboration and intertwining of strands. The other aspects of RME that were evident were the notion of Mathematics as a human activity, and that activities should be based on real life situations.

The third theme was the participants’ considerations and ideas about ICT that they observed in the app. They were able to identify a number of positive aspects that the app offered in terms of ICT, and also pointed out some challenges. I explored the participants’ opinions about different devices. The discussion centred on the use of mobile devices and the suitability thereof for the app. Participants also shared their thoughts on technology as an educational tool. I discussed factors that related specifically to the participants with regard to factors of ICT.

I discussed the data which related to the theme of role players, and considered the participants’ views regarding the role of the teacher; the learner; the community and the context. They emphasised the importance of each of the role players and mentioned specific ways in which they could influence the use of the app. The final aspect that I discussed was suggestions that the participants made relating to the app. I discussed the usability of the app, where participants shared their ideas on the usefulness of the app. This was followed by a discussion of what they perceived to be positive about the app and also suggestions that they made to improve the app. I discussed these suggestions in three categories, namely: pedagogical issues, design aspects and as well as general suggestions.

By presenting the participants with the app and allowing them the opportunity the offer their observations and evaluation thereof, the first cycle of the final phase of the design-based research process had been completed. In figure 2.6 I illustrated this as the final evaluation cycle. I ended the preceding two chapters with design principles that were derived from the analysis of the interview data and the design process of the app. I will proceed to do the same in this chapter. Since this phase also completes a cycle (final evaluation) of the semi-summative evaluation phase (Figure 2.6), the outcome here too will be design principles, which this time will relate to the evaluation of the mobile app for Financial Mathematics.
Table 6.2 Design Principles for the Design of a Mobile App Based on the Principles of
Realistic Mathematics Education Derived from Focus Group Interviews with
Participants

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Design Principles</th>
</tr>
</thead>
</table>
| Participants’ observations of the app in terms of Mathematics | • The immediate feedback that users are provided with is useful
• Working with the app promotes motivation
• The content knowledge of a teacher is essential in effectively implementing the app
• All areas of the curriculum are suitable for such an app
• A variety of learners with varying needs can be catered for by the app
• The app can promote the classroom climate through the use of competitions and games |
| Facets of RME observed in the app | • The app is able to present content based on the characteristics and aspects of RME |
| Considerations concerning ICT in the app | • Mobile technology is a suitable means of presenting the app
• Teachers should guard against using the app only, there should be written activities as well
• Teachers are required to have basic technology skills such as being able to download the app from Goole App Store
• The older generation of teachers may need more assistance with ICT than the younger generation |
| The effect of role players on the use of the app | • The Mathematics teacher is the most prominent role player in the implementation of the app
• Parents play an important role in the successful use of the app
• Institutional and departmental issues might hinder the implementation of the app in teaching practice |
| Suggestions form participants about the app | • The app should comply with the aspects that define usability of the app, namely effectiveness, efficiency and satisfaction
• The app should be extended to other subject areas
• The app should present a variety of questions to cater for slow learners and cover the full spectrum of the curriculum
• Hints and scaffolds should be used wisely and on request, after allowing the user sufficient opportunities to make their own attempt on activities
• More interactivity should be incorporated. Consider aspects that can aid interaction outside of the app such as WhatsApp™
• The app should be presented with sound and more visual aspects—less text should be used
• Animation should be considered for future designs |
Chapter Seven
Guidelines for the Effective use of Technology in Implementing the Realistic Mathematics Education Approach in Teaching Practice

7.1 Introduction

The study was underpinned by the main research question: What are the guidelines for the effective use of technology in implementing the RME approach in teaching practice? This chapter addresses this research question and presents a voluptuous overview of the research journey. I start with a detailed overview of the preceding chapters and also address the research questions. I also present the envisaged guidelines for the effective use of technology in implementing the RME approach in teaching practice. I discuss the contribution that this study has made to the field of Mathematics education and will also mention the limitations of the study. Future questions that arose from the study are presented and I also share my reflections of the research journey which I undertook.

7.2 Summary of Chapters

In this section a summary of the first six chapters will follow.

7.2.1 Chapter One: Orientation to the Research Journey

Chapter One provided an orientation for this research and presented a detailed plan of the research report that followed. It sketched the problem situation that needed to be investigated and provided a motivation for doing the research. I explored the existing literature and pointed out the gaps in that literature. A literature review concerning the main themes of the study was presented. The discussion of the literature revolved around three themes: RME; the use of technology in Mathematics education; and the relationship between RME and technology. I then presented the research questions and the purpose of doing this research. An overview of the research design and methodology was discussed and issues such as the population; participant selection; methods of data generation; and analysis were mentioned. I detailed a review of the methodology of a qualitative design-based research study and discussed the ethical implications thereof. This chapter also provided a list of terminology for clarification and mentioned the contribution that the study might make towards the field of Mathematics education.
7.2.2 Chapter Two: Research Design and Methodology

In Chapter Two the detailed research design and methodology was presented. Upon closer inspection of the research questions, the research approach and method was selected and presented in detail. This chapter provided the roadmap of the research process that was to follow. I discussed the theoretical underpinnings of a qualitative design-based research study from an interpretivist perspective. After exploring the literature concerned with design-based research, I discussed the various phases of this design-based research process applicable specifically to this study. The necessary ethical considerations were documented. In Chapter Two I presented a comprehensive documentation of the systematic literature review process that I followed. This discussion included a description of the document search process; the criteria according to which the documents were selected; the measures followed to assure quality assessment of the documents and a description of how the data were analysed with the aid of ATLAS.ti™. In this chapter I also presented the codebook relevant for this study. I indicated the manner in which validity and reliability issues were adhered to and discussed the limitations of the systematic literature review.

The chapter continued to explain the processes and methods followed in the first qualitative strand—the needs analysis. Here I discussed the criteria for the selection of the participants and the selection of the site. The data for the needs analysis were in the form of individual semi-structured interviews with the teacher-students. Data were analysed with the aid of ATLAS.ti™ in the same HU as the systematic literature review. The next phase of the research that I reported on in this chapter was the second qualitative strand in which I determined the teacher-students’ perceptions of the intervention tool, which took the form of a mobile app. In this section I also discussed the participant and site selection. Data were collected through two focus group interviews and the analysis was also done with the aid of ATLAS.ti™ in the same HU. I finalised the chapter with an illustration of how validity and reliability were ensured in the qualitative inquiry and gave a description of the role that I played as researcher.

7.2.3 Chapter Three: Systematic Literature Review

Chapter Three provided a report of the systematic literature review of the current literature that pertained to the use of ICT in the implementation of the RME approach in Mathematics education. The systematic literature review revealed five themes: Mathematics; RME; ICT; methodology; and role players. The discussion on Mathematics revolved around seven aspects. These aspects were as follows: the factors that influence teaching and learning were discussed; the impact of RME and technology on Mathematics education; the influence of different teaching approaches on teaching practice; ways in which meaningful learning could be established and promoted; different teaching methods and strategies, which included the use of models; the effect of RME and technology on mathematical content; and various aspects that relate specifically to learners such as learner understanding and learner reasoning.
The second theme was that of RME. I first discussed the theory of RME, followed by the characteristics, aspects and principles of RME. The five characteristics of RME featured throughout the study as did the three principles of guided reinvention, emergent modelling and didactical phenomenology. Specific aspects that related to RME were also explored such as the implementation of tasks in RME; the use of HLTs; and the use of real life contexts. The chapter continued with a report on the advantages, disadvantages and recommendations for RME.

The third theme of this chapter was ICT. I explored the value of using ICT in Mathematics education as well as the challenges that go with its use and implementation. I also discussed different ICT tools and devices that were apparent in the systematic literature review. The discussion on devices concentrated mainly on mobile tools such as smartphones, tablets, and calculators. I extended this discussion on ICT by exploring virtual learning environments and the connection between ICT and the RME approach to teaching Mathematics.

The next theme that was discussed was methodology. The emphasis was on design-based research specifically since it featured as the chosen methodology for this study. The final theme that was explored in this chapter was role players. In this chapter I discussed only two sub-themes for role players, namely the role of teachers and the role of learners. In further thematic analyses in this study, I extended these to other relevant role players.

7.2.4 Chapter Four: Participants’ Needs and Perceptions with regard to Real Life Mathematics

In Chapter Four I reported on the data that were gathered through the individual interviews with the teacher-students. The purpose of gathering this data was to assemble sufficient information to answer the research question: What support needs do teachers have in order to successfully implement the RME approach in their teaching practice? The data were coded in ATLAS.ti™ in the same HU as the systematic literature review, which meant that the same codes as well as some additional codes were used for this process. Four of the five main themes from the systematic literature review were addressed in the analysis and were discussed. These themes were Mathematics, RME, ICT and role players. I centred the discussion on the teacher-students’ needs and perceptions in terms of Mathematics and divided the category into three sub-themes, namely factors that influence teaching and learning; mathematical content and learner aspects. The focus in the section on mathematical content was particularly on problem areas that the teacher-students had in terms of teaching the mathematical content and also areas of the content which in their opinions was related to real life.

The discussion continued to the theme of RME. Here, as with the systematic literature review, I looked at the characteristics, aspects and advantages of using RME as expressed by the teacher-
students in the interviews. In the section on characteristics, the analysis centred on student contributions; interactivity; the use of context problems; modelling; and the integration of different strands of the curriculum. The next theme that was discussed was ICT. Five sub-themes for ICT emerged in Chapter Four. These included the value of using ICT; challenges experienced when working with ICT; devices; technology as an educational tool; and teacher-student ICT factors. The latter two themes (and codes) were introduced at this point to cater for the data relating to the teacher-students’ needs and perceptions of ICT in Mathematics education. In the section on technology as an educational tool, I explored factors such as the teacher-students’ use of WhatsApp™ in their teaching as well as other educational tools such as web-based interactives and GeoGebra. The final theme that was discussed in this chapter was the various role players. In this chapter it was necessary to discuss the data under four sub-themes, namely the roles of the teacher; learner; community; and context. In the section on the role of the community, the role of parents featured strongly as a factor that influences learner motivation. Under the role of the context I explored the teacher-students’ opinions about the importance of facilities at schools as well as departmental factors that play a role in effective education. The final stage of this chapter was a summary of the design principles relevant to the data obtained from the individual interviews.

7.2.5 Chapter Five: The Design and Development of the Mobile Intervention Tool

Chapter Five encompassed a report on the design phase of this study. The intervention tool, which was in the form of a mobile app on Financial Mathematics, was designed to assist teacher-students with incorporating the characteristics of RME into their teaching practice. This chapter detailed the process that was followed in the design of that app. Firstly I addressed the purpose of designing the app. I explored the theoretical underpinnings for the design process and reported on current literature relating to mLearning. I concentrated on mLearning in Mathematics specifically; and again considered the connection between technology and RME, in particular the role that technology played in this approach to teaching Mathematics. I briefly sketched the context for which the app was designed by reporting on the teacher-students’ contexts. I then continued to explain the process that was followed with regard to the design of the app. A team consisting of myself, a programmer; my promoter, an expert in the field of using technology in teaching and learning; and my assistant promoter, an expert in Mathematics and Mathematics education, were involved in the design process. I discussed the theoretical aspects of designing the app and also explained how the design process proceeded according to the phases of a design-based research methodology. The various stages of prototyping were discussed, as well as how the app was designed based on the characteristics and principles of the RME approach. The final part of this chapter explored the technical aspects of creating the app. Here nine specific steps were followed and these were discussed in this section. I also drew the comparison of the nine steps that we followed with the five design steps suggested in literature. The chapter ended with a summary of the design principles that were relevant for this design process.
7.2.6 Chapter Six: Participants’ Observations and Experiences of the Mobile App

In Chapter Six I reported on the data that were obtained from the focus group interviews in which teacher-students were introduced to the app. Their observations and experiences of the app were recorded and analysed. The data were analysed in ATLAS.ti™ as an integrated data set in the same HU unit as all the other data in this study. The chapter presented this data analysis under five themes. The first four themes were familiar themes that arose in the systematic literature review and were also used in the data analysis presented in Chapter Four. These themes were Mathematics, RME, ICT and role players. An additional theme was created for the discussion of the data which centred on specific aspects relating to the app. Additional codes were also created to code and analyse this data. The subsequent extension of the codebook was presented in this chapter.

In the first theme, the focus was on observations about Mathematics that the teacher-students made in the app. The discussion was presented in five sub-themes: factors that influence teaching and learning; mathematical content; learner aspects; teaching methods and strategies; and meaningful learning of Mathematics. Factors such as the importance of immediate feedback; the role of teachers’ mathematical content knowledge; modelling; and the creation of a positive classroom climate were discussed. The second theme that was discussed was facets of RME that the teacher-students observed in the app. Here I discussed two aspects that arose from the data, namely the characteristics of RME and also aspects of RME. Teacher-students’ observations and experiences of ICT in the app were discussed next. The same five sub-themes were discussed here that were discussed in Chapter Four. These were the value of ICT; challenges when working with ICT; devices; technology as an educational tool and teacher-student ICT factors. Of importance here was a discussion on the benefits of using mobile technology specifically and also the challenges involved with the older generation with regard to adopting new technology. An interesting comparison was drawn between opinions that one teacher-student had about ICT before using the app compared to after having used the app. The teacher-students’ aspiration to move forward was also discussed in the section.

The same role players featured in the discussion of the focus group data as was discussed in Chapter Four. Issues relating to the roles of teachers, learners, the community and the context were discussed. Once again, the role of parents as well as departmental issues was presented in the discussion. The final theme of this chapter was that of specific aspects relating to the app. Three sub-themes were explored. Firstly, the usability of the app, where I mentioned how teacher-students experienced the ease of use of the app, was discussed. I continued the discussion by investigating positive aspects that they experienced when working with the app and also suggestions that they made to improve the app. The discussion on suggestions was categorised into three divisions, where I discussed their suggestions in terms of pedagogical aspects; design aspects and general aspect that need to be considered for future design. This chapter concluded with a summary of design principles that were gathered from the focus group interviews.
7.3 Addressing the Research Questions

In order to effectively answer the main research question of this study, two sub-questions were posed to gain insight on the main question. These sub-questions were:

1. How can the use of the RME approach, facilitated by technology, enhance teaching practice?
2. What support needs do teachers have in order to effectively implement the RME approach in their teaching practice?

The first sub-question of this study: *How can the use of the RME approach, facilitated by technology, enhance teaching practice?* was addressed in Chapter Three the culmination of the systematic literature review. This chapter presented the current literature that existed relating to the effect of the RME approach, facilitated by technology, on teaching practice. The three most dominant themes that were discussed in this chapter were Mathematics, RME and ICT. The discussion illustrated the interaction between these three themes and discussed what literature revealed about how the RME approach, assisted by technology, could enhance teaching practice.

The second sub-question of the study: *What support needs do teachers have in order to effectively implement the RME approach in their teaching practice?* was addressed in Chapter Four, the analysis of the individual interviews with the teacher-students. This chapter presented the analysis of data that revolved around the needs analysis of the teacher-students. The data were analysed with ATLAS.ti™ and revealed the teacher-students’ needs in terms of teaching Mathematics. The content areas that they found problematic to teach as well as the areas of the curriculum that their learners found challenging was revealed. They also disclosed which areas of the curriculum they found difficult to relate to real life. The discussion also divulged aspects relating to the theory of RME that were important to the teacher-students, and they shared their views about using ICT in their teaching of Mathematics.

In order to address the main research question which guided the research: *What are the guidelines for the effective use of technology in implementing the RME approach in teaching practice?* I created an inventory of all the design principles that have emerged from this study. These design principles have been re-categorised according to the five main themes that were prevalent throughout the study: Mathematics, RME, ICT, role players, and aspects relating to the app. Table 7.1 presents a summary of the guidelines.

<table>
<thead>
<tr>
<th>Prevalent themes of this study</th>
<th>Guidelines for the effective use of technology in implementing the RME approach in teaching practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>• Establish what needs the teacher-students have with regard to content areas (both teachers and learners)</td>
</tr>
<tr>
<td></td>
<td>• Mathematics content should be rich and accurately presented</td>
</tr>
</tbody>
</table>

Table 7.1 Guidelines for the Effective use of Technology in Implementing the Realistic Mathematics Education Approach in Teaching Practice
<table>
<thead>
<tr>
<th>Prevalent themes of this study</th>
<th>Guidelines for the effective use of technology in implementing the RME approach in teaching practice</th>
</tr>
</thead>
</table>
|                               | • Interactions with the content should be engaging  
|                               | • Users must be given the opportunity to reflect on tasks  
|                               | • Hints and scaffolds should be used wisely and on request, after allowing the user sufficient opportunities to make their own attempt on activities  
|                               | • The immediate feedback that users are provided with is useful  
|                               | • Working with the app promotes motivation  
|                               | • The content knowledge of a teacher is essential in effectively implementing the app  
|                               | • All areas of the curriculum are suitable for such an app  
|                               | • A variety of learners with varying needs can be catered for by the app  
|                               | • The app can promote the classroom climate through the use of competitions and games  

**RME**

- Meaningful, realistic contexts should be the foundation for students to reinvent the Mathematics  
- Establish teacher-students’ needs in terms of making Mathematics realistic for the learners  
- User contributions should be encouraged  
- Incorporate the use of modelling  
- Make use of interactivity  
- Ensure the intertwining of content areas and concepts  
- Users ought to be given the opportunity to invent their own strategies to solve problems

**ICT**

- Teacher-students should see the value of ICT when using such an intervention tool  
- The challenges that teacher-students experience with regard to ICT should be addressed as far as possible  
- Establish which devices the teacher-students find most suitable  
- Determine in what manner teacher-students use technology as an educational tool  
- Mobile technology is a suitable means of presenting the app  
- Teachers should guard against only using the app, there should be written activities as well  
- Teachers are required to have basic technology skills such as being able to download the app from Google App Store  
- The older generation of teachers may need more assistance with ICT than the younger generation

**Role players**

- Teachers are the key role players in integrating ICT in teaching and learning  
- Learners’ learning is influenced by their socio-economic circumstances  
- Parents play an essential role in learners’ academic performance  
- Facilities and higher authorities can be important within the given context  
- The Mathematics teacher is the most prominent role player in the implementation of the app  
- Parents play an important role in the successful use of the app  
- Institutional and departmental issues might hinder the implementation of the app in teaching practice  
- Participants should indicate a desire to be involved in professional development  
- Participants must aspire to move forward

**Aspects relating to the app**

- A detailed design document should be created  
- The problem situation should be clearly sketched  
- The purpose of the app must be clearly defined from the start  
- The different prototypes should be rigorously tested by a range of parties (novices and experts)  
- User interaction with the app should be encouraged  
- The app should comply with the aspects that define usability of the app, namely effectiveness, efficiency and satisfaction  
- The app should be extended to other subject areas  
- The app should present a variety of questions to cater for slow learners and cover the full spectrum of the curriculum  
- More interactivity should be incorporated. Consider aspects that can aid interaction outside of the app such as WhatsApp™  
- The app should be presented with sound and more visual aspects—less text should be used  
- Animation should be considered for future designs
The guidelines relating to Mathematics centre around three main categories: mathematical content, teaching and learning strategies and classroom ethos. The majority of the guidelines refer to mathematical content with the focus on rich and accurate presentation of the content; content that is engaging; and the importance of teachers’ mathematical content knowledge. With regard to strategies—factors such as scaffolding, hints and immediate feedback were found to be useful tools in this study. Classroom ethos also featured in the guidelines. This refers to factors such as motivation and classroom climate. The study revealed how these factors could be promoted by the app.

The guidelines that centred on the theme of RME focused on the characteristics of RME. The importance of incorporating realistic contexts to allow for students to reinvent Mathematics is an important guideline. The use of modelling; interactivity and ensuring the intertwining of strands was essential in this study. With regard to ICT, the guidelines were varied, yet an important characteristic of the ICT guidelines was: taking into account the teacher-students view of different aspects of ICT. These included what they saw as challenges with ICT; the value they perceived of ICT; the devices and tools they felt comfortable with as well as the skills they had and were required to have to effectively use the technology.

The guidelines concerned with role players again centred on teachers, learners and contexts. The focus was on guidelines relating to teachers since they featured as the key role players in this study. Guidelines relating to parents and institutional matters were important factors when considering the implementation of the app. The final set of guidelines related to aspects relating to the app. The guidelines here were categorised into four categories. Various guidelines dealt with the phases of design, which included defining a definite purpose, proper planning and rigorous testing of the app. Some guidelines concerned with pedagogical issues were raised such as using different questions for a variety of learners and also for full coverage of the curriculum. Various guidelines relating to the usability of the app were revealed, and finally a number of guidelines were suggested for future development, such as including sound and animation.

The involvement of the NWU in the effective use of technology in implementing the RME approach in teaching practice is at the level of expanding the app to a wider range of teacher-students with more apps that cover the entire curriculum. Another guideline that has implications for the NWU is to expand the project to other subject areas other than Mathematics. This has cost implications that the university would have to consider. Either way, the NWU has a responsibility to assist in improving the Mathematical content knowledge of the teacher-students.

At the level of the lecturer, her or his involvement would be quite extensive in effectively using technology to implement RME in teaching practice. Most of the guidelines related to Mathematics would be the lecturer’s responsibility, such as establishing the teacher-students’ needs; creating content that is rich and accurately presented; designing the app to provide immediate feedback; and incorporating aspects such as competitions and games in the app to promote a positive classroom
climate. In the guidelines relating to RME the responsibility rests on the lecturer and the teacher-students. It is the lecturer’s responsibility to teach and implement the characteristics of RME in any intervention tool that is designed for the teacher-students, and it would be the teacher-students’ responsibility to then implement those characteristics in their own classrooms for their learners.

In the guidelines relating to ICT, the responsibility is also shared mainly between the lecturer and the teacher-students. The lecturer needs to establish various aspects about the teacher-students in order to design the intervention such as establishing what device is most suitable, and in what manner the teacher-students are willing to use technology as an educational tool. The teacher-students on the other hand initially need to acquire certain skills, if they do not already have those, like being able to download an app. Thereafter, when implementing the technology in their teaching, they need to guard against relying too heavily on technology in the classroom and should be able to balance written activities and exercises with the use of technology.

Teachers feature most strongly in the guidelines about role players. They feature as the key role players in implementing the RME approach in their teaching practice. Concerning the aspects relating to the app, it is the lecturer’s responsibility to plan, create and test a well-defined tool for intervention. The lecturer should also ensure sufficient and appropriate questioning to suit all learners.

With reference to Figure 2.6, the final phase of a design-based research project is the semi-summative evaluation phase. As discussed in §6.7, the teacher-students’ evaluation of the app (Chapter Six) accounted for the final evaluation stage. The final stage of the entire process is the generation of guidelines (Figure 2.6). The guidelines presented above constitute the completion of the design-based research process for this study.

In §2.4 I discussed that design-based research should generate evidence-based claims about learning that addresses theoretical issues and generate theoretical knowledge in the field, rather than show that a particular design works (Barab & Squire, 2004, p. 6). In this study, the guidelines that have been produced are able to provide specific strategies that should be followed when using technology to implement the RME approach in teaching. The guidelines are related specifically to themes that were dominant throughout the study. I have also discussed where the responsibility to carry out these guidelines lie, namely with the NWU, the lecturer or the teacher-student. Therefore, these guidelines have contributed to the theoretical knowledge in the field, and certainly did address relevant theoretical issues.

7.4 Contribution of the Study

The study contributes to the subject area and discipline of Mathematics in the following manner:
• The systematic literature review proved to be an invaluable tool in providing clarity and insight into the RME approach, as facilitated by technology, in enhancing teaching practice.
• The study contributed towards the discipline of Mathematics by providing insight into the needs that teacher-students have with regard to making Mathematics more realistic for their learners.
• The initial evaluators of the app found it to be practical, suitable and meaningful in the area of Mathematics education. They also felt it could contribute to a wider range of students than those involved in the study and recognised the contribution it could make if designed for other content areas as well.
• Teacher-students were given the opportunity for a robust exchange of ideas that contributed to enhance and enrich the study.
• The teacher-students were exceptionally positive about the app and its potential for a wider range of Mathematics teachers as well as their learners.
• The teacher-students found their participation in the study rewarding and shared how much they had learned in the process.
• The guidelines that were produced are practical, hands-on and meaningful pointers that can be used for future developments in the area of enhancing Mathematics education with technology.
• The design principles that were produced in this study have the potential to inform lecturers, instructional designers and curriculum experts in the design and adaptation of course material for students.
• Teacher-students and their learners have benefitted from the app since the mathematical content was presented in a relevant and realistic way.
• The study has the potential to be the start of a larger project in the Faculty of Education Sciences at the NWU where student-teachers can be supported in their Mathematics teaching practice through mobile technology.
• This thesis will contribute to the research output of the Research Focus Area Self Directed Learning (SDL) at the NWU.

7.5 Limitations of the Study

The limitations of this study relate at two levels, a methodological level as well as a practical level. Firstly, methodologically this study was a qualitative study that was seated in the interpretivist paradigm. This meant that it accounted for one quadrant or perspective in Figure 2.2 by Burrell and Morgan (1994, p. 22) on paradigms for the analysis of social theory (§ 2.2.2). The study might have been richer if the perspectives of the teacher-students could have been quantified by including a quantitative component to the study. This was my first attempt at a qualitative study, which could have impeded on its success; however, issues of trustworthiness proved the validity of the study.
On a practical level, the second area that might have limited this study was the small number of respondents that were used. The possibility exists that if more participants had taken part in the study, the results might have been different. However, data saturation was achieved with the participants in this study, which implied that it was not necessary to extend the study to any more participants (§ 2.8.3.2).

7.6 Future Questions

The study revealed the following future research questions:

- What are the most important factors that hinder Mathematics teachers from implementing technology in their teaching of Mathematics?
- What effect does teachers’ mathematical content knowledge have on the implementation of the RME approach in their teaching?
- What effect does teachers’ technological content knowledge have on the implementation of the RME approach in their teaching?
- How can parental support enhance learners’ experience of Mathematics?
- How should hints and scaffolds be used in the design of a mobile intervention tool to effectively guide users through mathematical content?
- How does the interaction between users of a mobile tool influence their academic achievement in Mathematics?
- How do teachers incorporate the use of a mobile tool in the teaching of Mathematics?

7.7 Reflections on my Research Journey

I am fervent about teaching, in particular teaching Mathematics. My journey began as a high school Mathematics teacher, where I gained invaluable experience on the teaching and learning of Mathematics. There I developed a desire to assist other teachers in their efforts to make Mathematics more meaningful for their learners. I advanced to a lecturing position at the NWU, and here have the privilege of training and assisting Mathematics teachers.

As a researcher, my first experience with research was with quantitative research. Because of my love for working with numbers and statistics, this was the obvious choice. I enjoyed doing quantitative research and found it fairly easy to do. However, being a person, who likes to be challenged, I decided that I wanted to learn more about qualitative research. The research question for my PhD study steered me in the direction of qualitative research and gave me the opportunity to explore my interest with this type of research. I found the process challenging but rewarding.
Firstly, doing a systematic literature review was a fascinating process. That which appeared to be cumbersome in the beginning, turned out to be a highly structured frame according to which I could analyse the rest of the data in the study. This structure that the systematic literature review provided was familiar and comforting to me, the mathematician. I found the idea of having to do interviews daunting since I had no experience in that field. Yet I quickly felt comfortable for two reasons: I was discussing issues of Mathematics education that are crucial to me, and I was discussing them with people that I care for, my Mathematics teacher-students. I quickly got the gist of acting as an interviewer and enjoyed hearing my students’ ideas on and opinions of aspects important to all of us.

The design process of the app was also a completely new experience for me. Although I have been involved in creating and designing course material at secondary school and tertiary level, I had no experience in designing material to be implemented by a technological tool. Since my second passion after Mathematics is technology, this was an exciting and stimulating process. The excellent support that I received from my promoter and the programmer helped to make the design process smooth and enjoyable. So much so that I would love to extend this study to many more apps that cover the entire Mathematics curriculum.

Experiencing the feedback from the teacher-students after introducing them to the app was a fulfilling experience. Because I am fully aware of their circumstances and contexts, being able to provide them with a tool that can assist them in their jobs was gratifying. Their reaction to the app was so positive, and they too could see the potential thereof for their daunting task as Mathematics teachers as well as for the learners that they are responsible for. It was also satisfying to notice a positive change in one of the teacher-students’ perception of technology use in the Mathematics classroom.

By doing a qualitative study, I was able to experience the human side of Mathematics and technology, which in my Master’s dissertation was much more quantitated. Although I had the desire to learn more about qualitative research, I was apprehensive as to how I would cope with the process. The experience exceeded my greatest expectations; I found the journey of doing qualitative research fascinating, rewarding, enriching and enlightening. I would encourage any quantitative researcher to take the plunge and also give qualitative research a fair chance.
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ETHICS APPROVAL CERTIFICATE OF STUDY

Based on approval by the Ethics Committee of the Faculty of Education Sciences (ESREC) on 15/11/2016 after being reviewed at the meeting held on 26/11/2015, the North-West University Institutional Research Ethics Regulatory Committee (NWU-IRERC) hereby approves your study as indicated below. This implies that the NWU-IRERC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Guidelines for effective technology facilitation of Realistic Mathematics Education to enhance teaching practice.

Study Leader/Supervisor: Prof AS Blignaut
Research team: DJ Laubsher & Prof HD Nieuwoudt

Ethics number: NWU-HS-2014-0267

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: N/A
Commencement date: 2016-11-15
Expiry date: 2017-11-15
Risk: Minimal

Special conditions of the approval (if applicable):

- Translation of the informed consent document to the languages applicable to the study participants should be submitted to the ESREC (if applicable).
- Any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the ESREC. Ethics approval is required BEFORE approval can be obtained from these authorities.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The study leader (principle investigator) must report in the prescribed format to the NWU-IRERC via ESREC:
  - annually (or as otherwise requested) on the progress of the study, and upon completion of the project
  - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
- Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the proposal as stipulated in the application form. Would any changes to the proposal be deemed necessary during the course of the study, the study leader must apply for approval of these changes at the ESREC. Would there be deviation from the study proposal without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-IRERC via ESREC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-IRERC and ESREC retains the right to:
  - request access to any information or data at any time during the course or after completion of the study,
  - to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.
  - withdraw or postpone approval if:
    - any unethical principles or practices of the project are revealed or suspected,
    - it becomes apparent that any relevant information was withheld from the ESREC or that information has been false or misrepresented,
    - the required annual report and reporting of adverse events was not done timely and accurately,
    - new institutional rules, national legislation or international conventions deem it necessary.
- ESREC can be contacted for further information or any report templates via Erna.Conradie@nwu.ac.za or 018 299 4656

The IRERC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the IRERC or ESREC for any further enquiries or requests for assistance.

Yours sincerely

Prof LA Du Plessis
Digitally signed by Prof LA Du Plessis
Date: 2016.11.18
08:18:49 +02'00'

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1 January 2016

Mathematics Education student
School for Natural Sciences and Technology
Education
North West University
Potchefstroom
South Africa

Dear Sir / Madam

Permission to participate in research

I, Dorothy Laubscher, am enrolled for a PhD study at the Faculty of Education Sciences, Potchefstroom Campus of the North-West University. I am in the process of conducting research on the teaching and learning of Mathematics. The title of my thesis is: Guidelines for effective technology facilitation of Realistic Mathematics Education to enhance teaching practice.

You have been selected as part of a sample of participants to take part in the above-mentioned research project about the use of technology to make Mathematics teaching and learning more realistic. The project will involve an informal discussion with the researcher regarding your needs in the mathematics classroom in relation to making Mathematics content more realistic for the learners. Different technologies, like Facebook, WhatsApp™, Interactive Whiteboards etc. will be used to present content to you based on your teaching needs, as expressed in the informal discussion. Thereafter, interviews about your experience and opinions regarding the topic will be conducted. I hereby request your participation in this project.

I pledge to maintain the professional and research ethical codes. This signifies that:
• Your participation in this research remains voluntary and you may, at any time, withdraw from the research without any penalty
• Your personal information will at all times be treated as confidential
• No demands will be made on your academic teaching programme
• Should you be interested, the research findings will be made available to you and your school.

The Ethical clearance number for this study is NWU-HS-2014-0267.

Could you please provide me with your written consent by filling in the section on the next page. Your participation is voluntary. Your input and opinions are greatly appreciated!

Thank you for your willingness to complete this research.

Yours sincerely

Dorothy Laubscher
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Email: dorothy.laubscher@nwu.ac.za

Seugnet Blignaut
Promotor
Tel: 016 - 910 3514
Email: Seugnet.Blignaut@nwu.ac.za

Addendum 2.2
Informed Consent to participate in Research Project:

Guidelines for effective technology facilitation of Realistic Mathematics Education to enhance teaching practice

LETTER OF PERMISSION: RESEARCH PARTICIPANT

I, _______________________________________________, (name and surname)
a student from the North West University hereby give my permission to participate in the above mentioned research project. I am aware that my participation in this study remains voluntary and that I, at any time, may withdraw from the research. I understand that if I do not wish to participate in this research, it will not be held against me, as participation is voluntary. I also understand that all personal information will be treated as confidential by the researchers.

____________________________________________________
Signature

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Date
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<td>Drijvers P, Boon P, Doorman M</td>
<td>Digital design: RME principles for designing online tasks</td>
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<td>Heck A, Boon P, Bokhove C</td>
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Cohen’s Kappa for the Systematic Literature Review

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<th>Agree</th>
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<td>Agree</td>
<td>123</td>
<td>1</td>
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<tr>
<td>Researcher</td>
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<tr>
<td>Disagree</td>
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\[
p = \frac{(123 + 0)}{125} = 0.984
\]

\[
p_e = \frac{(\frac{124}{125} \times \frac{124}{125}) + (\frac{1}{125} \times \frac{1}{125})}{125} = 0.007873024
\]

\[
\text{Cohen's Kappa} = \frac{p - p_e}{1 - p_e} = \frac{0.984 - 0.007873024}{1 - 0.007873024} = 0.98387 = 1
\]

This calculation was confirmed at [http://graphpad.com/quickcalcs/kappa1.cfm](http://graphpad.com/quickcalcs/kappa1.cfm)
Number of observed agreements: 123 (98.40% of the observations)
Number of agreements expected by chance: 123.0 (98.41% of the observations)

Kappa = -0.008
SE of kappa = 0.006
95% confidence interval: From -0.019 to 0.003
The strength of agreement is worse than what you expect to see by chance alone.
Questions for the individual interview

1. What sections of the curriculum are most problematic for you to teach?
2. How often are you able to relate the content you are teaching to real-life situations?
3. Which sections of work do you think will be easiest to link to real-life situations?
4. In which sections of the curriculum do you need help to link the content to real-life situations?
5. Do you think it is important to relate your teaching to real-life situations? Explain your answer.
6. How do you feel about using technology in your teaching?
7. How do you feel about using mobile technology such as WhatsApp™ and SMS to discuss with me and other colleagues, possible ways of making the mathematics content more realistic for your learners?
8. How do you feel about being part of a WhatsApp™ group to discuss issues of making the mathematics more realistic?
9. What experience do you have with Facebook?
10. How do feel about using Facebook to discuss issues of making mathematics more realistic for your learners?
11. What experience do you have regarding interactive whiteboards?
12. How do you feel about using the interactive whiteboard to discuss issues of making mathematics more realistic for your learners?
13. What type of technology would you be most comfortable with for this project?

1. Watter afdelings van die kurrikulum is vir u die mees problematies om te behandel?
2. Hoe dikwels is dit moontlik vir u om die inhoud wat u onderrig te verbind aan alledaagse lewensituasies?
3. Watter dele van die werk dink u is die maklikste om te verbind aan alledaagse lewensituasies?
4. Met watter dele van die kurrikulum het u hulp nodig om die inhoud te verbind met alledaagse lewensituasies?
5. Dink u dit is belangrik om u onderrig te verbind aan werklke lewensituasies? Motiveer jou antwoord.
6. Hoe voel u daaroor om tegnologie te gebruik gedurende u onderrig?
7. Hoe voel u daaroor om mobiele tegnologie soos Whatsapp en SMS’e te gebruik om met my, en u ander kollegas, die moontlike wyse waarop wiskunde-inhoud meer realisties vir u leerders gemaak kan word, te bespreek?
8. Hoe voel u daaroor om deel te wees van 'n Whatsapp-groep wat die kwessies rondom wyses waarop wiskunde-inhoud meer realisties vir u leerders gemaak kan word, te bespreek?

9. Watter tipe ondervinding het u met Facebook?

10. Hoe voel u daaroor om Facebook te gebruik om die kwessies rondom wyses waarop wiskunde-inhoud meer realisties vir u leerders gemaak kan word, te bespreek?

11. Watter tipe ondervinding het u m.b.t. die interactiewe witborde?

12. Hoe voel u daaroor om die interactiewe witborde te gebruik om kwessies rondom wyses waarop wiskunde-inhoud meer realisties vir u leerders gemaak kan word, te bespreek?

13. Watter tipe tegnolgie sal u die mees gemaklikste mee wees om te gebruik tydens hierdie projek?
Cohen’s Kappa for Individual Interviews

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<td>1</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

\[
p = \frac{(207 + 0)}{209} = 0.990430622
\]

\[
p_e = \frac{(208 \times 208)}{209} + \frac{(1 \times 1)}{209} = \frac{0.990453515 + 0.000022893}{209} = 0.004738902
\]

\[
\text{Cohen's Kappa} = \frac{p - p_e}{1 - p_e}
\]

\[
= \frac{0.990430622 - 0.004738902}{1 - 0.004738902}
\]

\[
= \frac{0.9856172}{0.995261098}
\]

\[
= 0.990
\]

\[
\approx 1
\]

This calculation was confirmed at [http://graphpad.com/quickcalcs/kappa1.cfm](http://graphpad.com/quickcalcs/kappa1.cfm)
Number of observed agreements: 207 (99.04% of the observations)

Number of agreements expected by chance: 207.0 (99.05% of the observations)

Kappa = -0.005
SE of kappa = 0.003
95% confidence interval: From -0.011 to 0.002
The strength of agreement is worse than what you expect to see by chance alone.
Focus Group Interview Schedule

1. Why is mobile technology suitable to present Mathematics content in a realistic way?

2. How does this app address the principles and characteristics of RME?

3. How can this app assist teachers to teach Mathematics in a meaningful way?

4. What knowledge of technology would a teacher need to effectively use the app?

5. Which role-players will influence the use of an app such as this in the school situation?

6. How did you experience using this app?

7. How would you use this app to improve your teaching practice?

8. Which sections of the curriculum would benefit most from an app such as this one?

9. What can be done to improve this app?

Content

Problem situation

Sipho has decided to buy a bicycle so that he can attend soccer training in the afternoons at his school. Sipho visited the local stores and found a bicycle that he likes for R1299.

He has three options to consider. The store offers hire-purchase to buy the bicycle over a period of two years at 14% p.a. simple interest, (his dad will need to do the hire-purchase for him). He could also borrow the money from his dad who agreed that he can pay it back over 1 year at 13% p.a. simple interest. The third option is to borrow the money from his older brother Peter, who agreed to a 2 year period at 8% compound interest.

Questions:

1. Which is the best option for Sipho, considering he only earns R 150 pocket money a month? Motivate your answer.

2. Model an answer to show which of the three options is the most economical for Sipho (Which one does he pay the least interest)? Motivate.

Definitions: Click on the bold words in the problem to reveal their meanings

Interest When money is loaned, interest is charged for being able to use the money. When you invest money with a bank, you will be paid interest.

p.a. Is the abbreviation for per annum, it means per year.

Hire-purchase Goods like appliances can be bought on a hire-purchase loan. For hire-purchase, they usually require a 10% or 20% deposit. The interest is calculated at simple interest on the full loan amount over the period that it is repaid.

Simple Interest Simple interest is calculated on the original amount of a loan or investment.
Formula to calculate simple interest

Simple interest is calculated with the following formula:

\[ A = P(1 + i\cdot n) \]

where

- \( A \) is the total or accumulated amount.
- For investments, \( A \) is the amount invested plus the interest earned.
- For a loan, \( A \) is the total amount you have to pay back, the amount you borrowed plus the interest

- \( P \) is the amount borrowed or invested.
- \( i \) is the simple interest rate per annum (per year) (p.a.)

Remember that if the interest rate is 10% p.a. then

\[ i = 10\% \]

\[ i = \frac{10}{100} \]

\[ i = 0,1 \]

- \( n \) is the number of years that the money has been invested or borrowed.

Compound Interest

With compound interest, the interest is added to the capital amount at the end of each period.

Compound interest is interest on interest.

Long-term loans such as home loans make use of compound interest.

Formula to calculate compound interest

Compound interest is calculated with the following formula:

\[ A = P(1 + i)^n \]

where

- \( A \) is the future value of the money invested or borrowed. It includes the principal amount and the interest earned.
- \( P \) is the initial (principal) amount invested or borrowed
- \( i \) is the interest rate per annum, compounded annually
- \( n \) is the number of years for which the money has been invested or borrowed.
Hints to answer Question 1:

Do you know how what to do for the hire-purchase option?

Hint 1a: **Calculate the simple interest** for hire-purchase option

Need help with the formula?

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<th>No</th>
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<td>$A = P(1 + i \cdot n)$</td>
<td>If the formula is correct, go on to the next question. If something is incorrect, correct that as follows:</td>
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<td>If $P$ is not correct, give the hint:</td>
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<td>$P$ is the amount borrowed or invested</td>
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<td>If $i$ is not correct, give the hint:</td>
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<td>$i$ is the simple interest rate p.a.</td>
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<td>If $n$ is not correct, give the following hint:</td>
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<tr>
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<td>$n$ is the number of years that the money has been invested or borrowed.</td>
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</table>

Fill in the values you need for the formula

- $P = \square$ If incorrect then say: $P = 1299$ this is the amount you need to borrow
- $i = □\% = □$ If incorrect, then say $i = 14\% = 0,14$ the interest rate is 14% per annum (per year)
- $n = □$ If incorrect, they say $n = 2$ because you will pay back the money over a period of 2 years
Now fill these values into the formula

\[
A = P(1 + i \cdot n)
\]

= \boxed{\[1 + (0.14)(2)\]}

If the correct value (see below) is entered in the block

= 1299\[1 + (0.14)(2)\]

If the incorrect value is entered \(x\). If the answer is incorrect three times, then give the correct answer as follows:

\(P = 1299\) this is the amount you need to borrow

\(i = 14\% = 0.14\) the interest rate is 14\% per annum (per year)

\(n = 2\) because you will pay back the money over a period of 2 years

= \boxed{\[1 + \]}

If the correct value (see below) is entered in the block

= 1299\[1 + 0.28\]

If the incorrect value is entered \(x\). If the answer is incorrect three times, then give the correct answer as follows:

\(P = 1299\) this is the amount you need to borrow

\(0.14 \times 2 = 0.28\)

= \boxed{\[\]}

If the correct value (see below) is entered in the block

= 1299[1,28]

If the incorrect value is entered \(x\). If the answer is incorrect three times, then give the correct answer as follows:

\(P = 1299\) this is the amount you need to borrow

\(1 + 0.28 = 1.28\)
If the correct value (see below) is entered in the block  

= R 1662,72

If the incorrect value is entered x. If the answer is incorrect three times, then give the correct answer as follows:  

1299 x 1,28 = 1662,72

Do you know how what to do for the loan from dad option?

Hint 2a:  **Calculate the simple interest** for the loan from dad option

Need help with the formula?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = P(1 + i.n)</td>
<td>If the formula is correct, go on to the next question. If something is incorrect, correct that as follows:</td>
</tr>
<tr>
<td></td>
<td>If P is not correct, give the hint: P is the amount borrowed or invested</td>
</tr>
<tr>
<td></td>
<td>If i is not correct, give the hint: i is the simple interest rate p.a.</td>
</tr>
<tr>
<td></td>
<td>If n is not correct, give the following hint: n is the number of years that the money has been invested or borrowed.</td>
</tr>
</tbody>
</table>
What about the values to substitute?

\[ P = \square \]

If incorrect then say: \( P = 1299 \) this is the amount you need to borrow

\[ i = \square \% = \square \]

If incorrect, then say \( i = 13\% = 0,13 \) the interest rate is 13\% per annum (per year)

\[ n = \square \]

If incorrect, they say \( n = 1 \) because you will pay back the money over a period of 1 year

Now do the sum

\[ A = P(1 + i \times n) \]

\[ = \square[\square + (\square)\square] \]

If the correct value (see below) is entered in the block ✔

\[ = 1299[1 + (0,13)\times 1] \]

If the incorrect value is entered ×. If the answer is incorrect three times, then give the correct answer as follows:

\[ P = 1299 \] this is the amount you need to borrow

\[ i = 13\% = 0,13 \] the interest rate is 13\% per annum (per year)

\[ n = 1 \] because you will pay back the money over a period of 1 year

\[ = \square[1 +\square] \]

If the correct value (see below) is entered in the block ✔

\[ = 1299[1 + 0,13] \]
If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( P = 1299 \) this is the amount you need to borrow

\[
0,13 \times 1 = 0,13
\]

\[= \square\]

If the correct value (see below) is entered in the block \( \checkmark \)

\[= 1299[1,13]\]

If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( P = 1299 \) this is the amount you need to borrow

\[
1 + 0,13 = 1,13
\]

\[= \square \]

If the correct value (see below) is entered in the block \( \checkmark \)

\[= \text{R} 1467,87\]

If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( 1299 \times 1,13 = 1467,87 \)

---

Did you know that compound interest means that the interest is added to the capital amount at the end of each year? Keep this in mind and work out the compound interest using the simple interest formula.

---

**Hint 3a:** Loan at the end of the first year:

\[
A = P(1 + i \cdot n)
\]

\[= \square[1 + (\square)(\square)]\]

If the correct value (see below) is entered in the block \( \checkmark \)
\[ = 1299[1 + (0,08)(1)] \]

If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( P = 1299 \) this is the amount you need to borrow

\[ i = 8\% = 0,08 \] the interest rate is 8% per annum (per year)

\[ n = 1 \] Because you are working out the simple interest one year at a time

\[ = [1 + 0,08] \]

If the correct value (see below) is entered in the block \( \checkmark \)

\[ = 1299[1 + 0,08] \]

If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( P = 1299 \) this is the amount you need to borrow

\[ 0,08 \times 1 = 0,08 \]

\[ = [0,08] \]

If the correct value (see below) is entered in the block \( \checkmark \)

\[ = 1299[1,08] \]

If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( P = 1299 \) this is the amount you need to borrow

\[ 1 + 0,08 = 1,08 \]

\[ = R\] \( \Box \)

If the correct value (see below) is entered in the block \( \checkmark \)

\[ = R\] 1402,92

If the incorrect value is entered \( x \). If the answer is incorrect three times, then give the correct answer as follows: \( 1299 \times 1,08 = 1402,92 \)
What about the second year?

\[ A = P(1 + i.n) \]

\[ = \square[1 + (\square)(\square)] \]

If the correct value (see below) is entered in the block  
\[ = 1402,92[1 + (0,08)(1)] \]

If the incorrect value is entered \( \times \). If the answer is incorrect three times, then give the correct answer as follows:  
P = 1402,92 the interest from year one was added to the amount you borrowed.

\[ i = 8\% = 0,08 \] the interest rate is 8\% per annum (per year)

\[ n = 1 \] Because you are working out the simple interest one year at a time

\[ = \square[1 + \square] \]

If the correct value (see below) is entered in the block  
\[ = 1402,92[1 + 0,08] \]

If the incorrect value is entered \( \times \). If the answer is incorrect three times, then give the correct answer as follows:  
P = 1402,92 the interest from year one was added to the amount you borrowed.

\[ 0,08 \times 1 = 0,08 \]

\[ = \square[\square] \]

If the correct value (see below) is entered in the block  
\[ = 1402,92[1,08] \]
If the incorrect value is entered x. If the answer is incorrect three times, then give the correct answer as follows: $P = 1402.92$ the interest from year one was added to the amount you borrowed.

$$1 + 0.08 = 1.08$$

$$= R$$

If the correct value (see below) is entered in the block $R = 1515.15$

If the incorrect value is entered x. If the answer is incorrect three times, then give the correct answer as follows: $1402.92 \times 1.08 = 1515.15$

Now do the calculation for the loan from Peter. Do you need help?

Hint 4a: **Calculate the compound interest** for loan option from older brother Peter

Need help with the formula?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A = P(1 + i)^n$</td>
<td>If the formula is correct, go on to the next question. If something is incorrect, correct that as follows:</td>
</tr>
<tr>
<td></td>
<td>If A is not correct, give the hint: $A$ is the future value of the money invested or borrowed. It includes the principal amount and the interest earned.</td>
</tr>
<tr>
<td></td>
<td>If P is not correct, give the hint:</td>
</tr>
<tr>
<td>What about the values to substitute?</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>

| P = □ | If incorrect then say: \( P = 1299 \) this is the amount you need to borrow |
| i = □% = □ | If incorrect, then say \( i = 8\% = 0,08 \) the interest rate is 8\% compounded annually |
| n = □ | If incorrect, they say \( n = 2 \) because you will pay back the money over a period of 2 years |

<table>
<thead>
<tr>
<th>Now check if your answer is correct</th>
</tr>
</thead>
</table>

\[
A = P(1 + i)^n
\]

\[
A = □(1 + □)^\square
\]

If the correct value (see below) is entered in the block ✔

\[
= 1299(1 + 0,08)^2
\]

If the incorrect value is entered ✗. If the answer is incorrect three times, then give the correct answer as follows: \( P = 1299 \) this is the amount you need to borrow

\[
i = 8\% = 0,08 \text{ the interest rate is } 8\% \text{ per annum (per year)}
\]
n = 2 because you will pay back the money over a period of 2 years

= □(□)^2

If the correct value (see below) is entered in the block √

= 1299(1,08)^2

If the incorrect value is entered ✗. If the answer is incorrect three times, then give the correct answer as follows: P = 1299 is the amount you need to borrow.

1 + 0,08 = 1,08

= □(□)

If the correct value (see below) is entered in the block √

= 1299(1,1664)

If the incorrect value is entered ✗. If the answer is incorrect three times, then give the correct answer as follows: P = 1299 is the amount you need to borrow.

(1,08)^2 = 1,1664

= R □

If the correct value (see below) is entered in the block √

= R 1515,15

If the incorrect value is entered ✗. If the answer is incorrect three times, then give the correct answer as follows:

1299 x 1,1664 = 1515,15

Now compare the two answers you got for this option (using the simple interest formula and using the compound interest formula. What do you notice?
To answer Question 1: Payment per month:

Not sure how to work out which option is best?

Hint 5a: Calculate the monthly payment for each option

I don’t know what a monthly payment is....

Hint 5b: A monthly payment is how much money needs to be paid back per month to the person or place that it was borrowed from.

How do I calculate a monthly payment?

Hint 5c: Take the final amount from your calculation and divide it by the total number of months that the loan was taken out for.

Does your model have this information for the hire-purchase option?

Hire-purchase option

Payment per month = ☐

If the correct value (see below) is entered in the block ✓

= R 69,28 per month

If the incorrect value is entered ✗. If the answer is incorrect three times, then give the correct answer as follows:

Payment per month = R 1662,72 ÷ 24

= R 69,28 per month
Does your model have this information for the loan from dad option?

Loan from dad option
Payment per month = □

If the correct value (see below) is entered in the block  

= R 122,32 per month

If the incorrect value is entered  x . If the answer is incorrect three times, then give the correct answer as follows:

Payment per month = R 1467,87 ÷ 12
= R 122,32 per month

Does your model have the following information for the loan from Peter option?

Loan from Peter
Payment per month = □

If the correct value (see below) is entered in the block

= R 63,13 per month

If the incorrect value is entered  x . If the answer is incorrect three times, then give the correct answer as follows:

Payment per month = R1515,15 ÷ 24
= R 63,13 per month
Which is the cheapest option in term of monthly payments? □

If answer is Peter ✓

If any other answer x. If the answer is incorrect three times, then give the correct answer as Peter.

To answer Question 2: The most economical option (the least interest paid):

Hire-purchase option: Interest = □

If answer is R353,72 ✓

If answer is incorrect then x

Interest = Final amount – Initial amount

Interest = R 1662,72 – R 1299

= R 353,72

Loan from dad option: Interest = □

If answer is R 168,87 ✓

If answer is incorrect then x

Interest = Final amount – Initial amount

Interest = R 1467,87 – R 1299

= R 168,87

Loan from Peter: Interest = □

If answer is R 216,15 ✓

If answer is incorrect then x

Interest = Final amount – Initial amount

Interest = R 1515, 15 – R 1299
= R 216, 15

Most economical option is □

If answer is loan from dad ✓

If answer is incorrect three times, then give the correct answer as loan from dad
Activity

1. Sarah needs to decide which option is the most economical for her. Create a model to give her advice and help her to decide.

2. What is the interest rate that they are charging for the hire-purchase?

Question 1:

Do you need help to start?   yes □   no □

If they say yes, then say: Create a model to work out how much money Sarah pays back over the 30 instalments, remember to include her deposit.

After that say:
Hire-purchase final amount = □

If they say no then: Hire-purchase final amount = □

If they say R 7889 then say – well done, that is correct

If they have a different answer, then say: Your answer is incorrect. Check that your model includes the following:

Final amount = Deposit + (monthly instalment x 30)
= R 599 + (R 243 x 30)
= 599 + 7290
= R 7889

What is your advice to Sarah? Choose the most economical option for her.

Cash Price of R 5999 □ OR Hire-purchase with deposit R 599 and R 243 monthly □

If they choose Cash Price then say – Well done, that is the correct choice

If they choose Hire-purchase then say: No that is not the correct choice. She will be paying back R 7889 on hire-purchase and only R 5999 for the cash price. Discuss with a colleague why the first option is the best for Sarah.

Question 2

Do you need help to work out what the interest rate is?

yes □ no □

If yes, then say: remember that Hire-purchase means Simple Interest and then say: Which formula do I use?

□ = □(□ + □.□)

If no then say: Which formula do I use?
The answer should be: \( A = P(1 + i \cdot n) \)

If the formula is correct, go on to the next question. If something is incorrect, correct that as follows:

If \( P \) is not correct, give the hint:
\( P \) is the amount borrowed or invested

If \( i \) is not correct, give the hint:
\( i \) is the simple interest rate p.a.

If \( n \) is not correct, give the following hint:
\( n \) is the number of years that the money has been invested or borrowed.

The answers should be:

\( P = 5400 \)

If \( P \) is incorrect three times, then say: Do you know why it is R 5400 and not R 5999? Because there was a deposit of R 599

\[ A = 243 \times 30 \]
\[ = 7290 \]
If anything above is incorrect three times, then display the correct answer

$$n = \frac{2}{\frac{1}{2}}$$

If $n$ is incorrect three times, then say: What happened to 30 months? It was converted to years.

Now check your answer

$$A = P(1 + i \cdot n)$$

$$= P[1 + \left(\frac{1}{2}\right)]$$

If the correct values (see below) are entered in the block then say ✓

$$7290 = 5400\left[1 + \left(\frac{2}{2}\right)\right]$$

If the incorrect values are entered then say x. If the answer is incorrect three times, then give the correct answer as follows:

$$7290 = 5400[1 + 2,5i]$$

$$7290 = 5400 + 13500i$$

$$7290 - 5400 = 13500i$$

$$1890 = 13500i$$

$$i = \frac{1890}{13500}$$

$$i = 0,14 = 14\%$$

What is the interest rate that they are charging for the hire-purchase?

$$i = \Box\%$$

The answer should be 14%. If correct then say: Well done, that is correct.

If the answer is incorrect three times, then display the correct answer.
Changes on 10/03/16

In brackets should read: Calculated at Compound Interest using the Simple Interest Formula

In brackets should read: Using the Compound Interest Formula

Sentence should be: Peter, your older brother, offers to lend you the money and agrees to a period of two years at 8% p.a. compound interest.
Please replace purchase with purchase.
Financial Maths

Solve option 2: You can borrow the money from your parents to buy the bicycle over a period of one (1) year at 15% p.a. simple interest.
Enter the formula to calculate simple interest.

\[ A = \frac{P \cdot (1 + \frac{r}{100} \cdot n)}{n} \]

Show results

Wrong values entered. Try again.
Please replace borrow with lend here

Sentence should be:
Peter, your older brother, offers to lend you the money and agrees to a period of two years at 8% p.a. compound interest.

Replace with:
Work out the Compound Interest using the Simple Interest formula.

Let’s work out the loan at the end of the first year.

See comment above

See comment above

Work out the Compound Interest using the Simple Interest formula.

Let’s work out the loan at the end of the first year.
Is it possible to put a ^ in the formula to indicate it’s a power of n?
Is it possible to put a \(^n\) in the formula to indicate it’s a power of \(n\)?

Please add a line: Discuss with a friend or colleague how this answer compares to the answer you got when using the simple interest formula.

Replace purchase with purchase

Please change the instruction to: Create a model to calculate the monthly payment.

Replace purchase with purchase

Is it possible to put a \(^n\) in the formula to indicate it’s a power of \(n\)?

Replace purchase with purchase

Replace purchase with purchase
Replace purchase with purchase

“interest” in the place of “interset”

The answer should be R363,72
After this screen we need to answer the question:

Which is the most economical option?  Option 1  Option 2  Option 3

If the answer is Option 1 then say: This is the incorrect answer, try again.

If the answer is Option 2 then say: Well done, this is the correct answer! Discuss with a friend or colleague possible reasons why this option has the lowest interest.

If the answer is Option 3 then say: This is the incorrect answer, try again.
Please change this to:
Do you need help to calculate the total amount repaid on the hire-purchase option?

Please change this to:
Enter the total amount repaid on hire-purchase:

Please add this as well: Create a model to work out how much money you pay back over the 30 installments.

Please change this to:
Enter the total amount repaid on hire-purchase:
Please change “friend” to “friend or colleague”.

Enter the total amount repaid on hire-purchase:
Financial Maths

Calculate the interest rate for the hire-purchase option.
Enter the formula to calculate simple interest.

\[ A = P \left( 1 + i \cdot n \right) \]

CHECK FORMULA

Wrong values entered. Try again.
Can we introduce the content section with the detailed problem and questions that need to be solved? Perhaps have a screen that sets the problem situation and asks both questions before any other information is given.

**Problem situation**
You have decided to buy a bicycle so that you can attend sport training in the afternoons at your school. You have visited the local stores and found a bicycle that you like for R1299. You have three options to consider. The store offers **hire-purchase** to buy the bicycle over a period of two years at 14% p.a. calculated at **simple interest**. You could also borrow the money from your parents who agreed that you can pay it back over 1 year at 13% p.a. calculated at simple interest. The third option is to borrow the money from your older brother Peter, who agreed to a 2 year period at 8% calculated at **compound interest**.

**Questions:**

1. Which monthly payment can you afford, considering you only earn R 120 pocket money a month?
2. Model an answer to show which of the three options is the most economical for you (Which one do you pay the least interest)?
They will not know that the highlighted words can be defined. Can we have a hint pop up or appear or something, so that they know to tap on the bold words.

When they are asked to work out the monthly payment and if they say they need help to work out the monthly payment, then the three options’ monthly payments can be seen. After the last one has been clicked, they must be asked the question again:
Can we introduce the activity section with the detailed problem and questions that need to be solved? Perhaps have a screen that sets the problem situation and asks both questions.

You want to buy a new TV. The following options are available for you:

Cash Price R 5 999

OR

Hire-purchase: Deposit R599 and only R 243 per month (30 installments)

1. You must decide which option is the most economical. Create a model to help make the decision.

2. What is the interest rate that the store is charging for the hire-purchase?
When they calculate the interest rate correctly, can we include a final line that says:

Well done, you have correctly calculated the interest rate to be 14%

Also if they needed help with the values, and then correctly enter the values and calculate the interest rate, can we include a final line that says:

Well done, you have correctly calculated the interest rate to be 14%
Changes to app 10-05-16

Can we introduce the content section with the detailed problem and questions that need to be solved? Perhaps have a screen that sets the problem situation and asks both questions before any other information is given.

Problem situation
You have decided to buy a bicycle so that you can attend sport training in the afternoons at your school. You have visited the local stores and found a bicycle that you like for R1299. You have three options to consider. The store offers hire-purchase to buy the bicycle over a period of two years at 14% p.a. calculated at simple interest. You could also borrow the money from your parents who agreed that you can pay it back over 1 year at 13% p.a. calculated at simple interest. The third option is to borrow the money from your older brother Peter, who agreed to a 2 year period at 8% calculated at compound interest.

Questions:

1. Which monthly payment can you afford, considering you only earn R 120 pocket money a month?
2. Model an answer to show which of the three options is the most economical for you (Which one do you pay the least interest)?
They will not know that the highlighted words can be defined. Can we have a hint pop up or appear or something, so that they know to tap on the bold words.

When they are asked to work out the monthly payment and if they say they need help to work out the monthly payment, then the three options’ monthly payments can be seen. After the last one has been clicked, they must be asked the question again:

Which monthly payment can you afford, considering you only receive R120 pocket money a month?
Can we introduce the activity section with the detailed problem and questions that need to be solved? Perhaps have a screen that sets the problem situation and asks both questions.

You want to buy a new TV. The following options are available for you:

Cash Price R 5 999

OR

Hire-purchase: Deposit R599 and only R 243 per month (30 installments)

1. You must decide which option is the most economical. Create a model to help make the decision.

2. What is the interest rate that the store is charging for the hire-purchase?
When they calculate the interest rate correctly, can we include a final line that says:

Well done, you have correctly calculated the interest rate to be 14%.

Also if they needed help with the values, and then correctly enter the values and calculate the interest rate, can we include a final line that says:

Well done, you have correctly calculated the interest rate to be 14%.
DESIGN OF A PROTOTYPE MOBILE APPLICATION TO MAKE MATHEMATICS EDUCATION MORE REALISTIC

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¹TELIT-SA, North-West University, Vanderbijlpark Campus, South Africa,
²SDL, North-West University, Potchefstroom Campus, South Africa

ABSTRACT

To enter the world of work, students require skills which include flexibility, critical thinking, problem solving, collaboration and communication. The use of mobile technologies which are specifically created for a context could stimulate motivation in students to recognise the relevance of Mathematics in the real world. South Africa in particular is a suitable location to use mobile learning across distance due to its viability, affordability and availability as opposed to web-based technology. The design team developed an app for financial Mathematics based on the principles of realistic mathematics education (RME) for mathematics teachers to use with their students. The paper describes the design process and general usability aspects of the formative evaluation of the prototype app for financial Mathematics. The authors suggest that a graphic artist becomes part of the design team to enhance the visual attractiveness of the app.

KEYWORDS

Realistic Mathematics Education (RME); mobile applications; Distance Education (DE); Android; interactivity; user interface.

1. INTRODUCTION

The rapidly changing information society influences the roles of learners and teachers (Gravemeijer, 2012). Future jobs require what Gravemeijer (2012) refers to as 21st century skills, which include “flexibility, critical thinking, problem solving, collaboration, and communication.” Gravemeijer (2012) emphasizes the importance of addressing these demands by investigating educational practices that may nurture these goals. Heck et al. (2007) are of the opinion that the use of mobile technology could increase motivation as well as performance in learners. Also, the use of real-life contexts stimulate motivation because the relevance of Mathematics can be seen in the real world (Risnawati et al., 2014).

Various reasons are offered for poor performance in Mathematics, which include: when topics are taught (Fauzan et al., 2013), inaccurate learning material, inadequate or outdated teaching methods, poor forms of assessment, students’ anxiety about Mathematics (Widjaja and Heck, 2003); and students’ negative attitudes towards Mathematics (Widjaja and Heck, 2003).

Mobile learning is a field that is rapidly expanding and it affords new possibilities to improve learning, especially in a distance education (DE) environment (Kizito, 2012). South Africa in particular is a suitable location to use mobile learning in distance education due to its viability and affordability as opposed to web-based technology (Kizito, 2012). The portability of mobile technology allows learners to work creatively and collaboratively (Zaranis et al., 2013). When used correctly, technology could promote critical thinking, improve problem solving skills and facilitate collaboration (Stols, 2012). Further research is required to determine how the mobile phone can effectively be used in testing in DE (Kizito, 2012).

This paper investigates the need for, and the design and development of, a mobile application which would assist Mathematics teachers in making their teaching and their students’ learning more realistic in terms of the context in which the learning takes place.
2. LITERATURE REVIEW

2.1 Realistic Mathematics Education

Mathematics teachers are challenged to develop Mathematics education that is in line with the dynamic conceptions of symbolizing and the development of meaning (Bakker et al., 2003). The role of the teacher is essential to understand how to teach effectively with technology (Drijvers, 2012). Digital tasks should be designed in such a way that students are encouraged to develop their own Mathematics. The teacher should guide the process and should know when to further explore a topic or concept and when to cease to investigate a topic (Drijvers et al., 2013).

The traditional approach to teaching Mathematics still dominate in many classrooms today (Fauzan et al., 2013). This approach is characterized by teachers who actively explain material and provide examples and exercises, while learners listen, write and perform the tasks the teacher requires (Gravemeijer, 2012, Widjaja and Heck, 2003). The social norms of traditional classrooms dictate that the teachers’ answers are always correct and that students should follow given procedures to reach correct answers, which are more important than reasoning (Gravemeijer, 2012). Learners seldom have the opportunity to understand the rationale behind algorithms that are taught to them (Risnawati et al., 2014). Such a traditional approach to teaching Mathematics is held responsible for the poor quality of Mathematics Education and students’ negative attitude towards Mathematics (Fauzan et al., 2013, Widjaja and Heck, 2003). Another consequence of traditional teaching is that when students solve word problems, high level cognitive and metacognitive processes are often absent (Mousoulides et al., 2007).

Reform from the traditional approach demands that curricula, teaching materials and assessment need to be adapted (Zulkardi, 2000). Freudenthal (1968), often regarded as the father of Realistic Mathematics Education (RME), opposes the traditional idea that the end result of the work of mathematicians is the starting point for Mathematics Education (Gravemeijer and Doorman, 1999). RME is regarded as a domain-specific instruction theory for the teaching and learning of Mathematics (Drijvers et al., 2013). The RME-based teaching and learning process promotes learner-centred learning (Fauzan et al., 2013). Problem solving through modelling leads to the design of activities that allow for students to deal with non-routine problem situations that demand the development of important mathematical ideas which can be extended, explored and refined in other problem situations (Mousoulides et al., 2007). Technological tools create new prospects for problem solving in Mathematics (Doorman et al., 2007). A cornerstone of RME is that students are encouraged to not only receive information, but also question and process information (Widjaja and Heck, 2003), actively participate in the educational process and develop mathematical tools and insights (Drijvers et al., 2013).

2.2 Mobile learning

Mobile technology offers a new generation of learning to students of all ages without being bound by place and time (Alzaaza and Yaakub, 2010). Mobile learning (mLearning) is becoming more popular within formal education as its benefits offer cost-efficiency, portability; instant connectivity; and context sensitivity. Mobile learning assists students to create social interaction; it promotes collaborative learning, interactivity and instant feedback as well as collaboration between peers; it improves their knowledge structure; their learning achievements and motivation (Mouza and Barrett-Greenly, 2015). Domingo and Garganté (2016) further point out that students are more willing to engage when learning with mobile technology; their desire to accomplish educational tasks also increases with the use of mobile technology, and it helps learners to become more self-directed in their learning. Mobile communication in education is a solution with a selection of prospects and challenges (Kommers and Hooreman, 2009).

mLearning applications have various educational benefits: they can be used as study aids; can be accessed from almost anywhere; and with the aid of location capabilities, students can use location-based information (Cheon et al., 2012). Mobile technology applications supplement higher education by extending traditional educational platforms and encouraging distance learning or using settings outside of the classroom (Al-Emran et al., 2016). Content applications that make use of personalized instruction can facilitate academic growth and self-efficacy among students (Mouza and Barrett-Greenly, 2015).
3. METHOD

This research relates to the first phase of a four-phased qualitative design-based research process where four teacher-students in the Open Distance Education (ODL) program of the North-West University (NWU), Potchefstroom Campus participated in individual interviews. They shared their perceptions and experiences on support teachers’ need in order to effectively implement the RME principles in their teaching practice. The teacher-students confirmed that their own students inter alia (i) had problems with certain areas of Mathematics, (ii) suffered challenges with the integration of the content across the curriculum, (iii) were excited about the affordances that mobile learning could bring to Mathematics education, and (iv) experienced challenges to link school Mathematics to real life problems, e.g. handling their own finances. The researchers decided to zoom in on the aspect of financial Mathematics for the content aspect of the mobile application (app) because all the participants mentioned this area as troublesome to their students.

The context in which the app will be used should form the anchor for the development of the content (Widjaja and Heck, 2003). The app was specifically designed for teacher-students enrolled in an open distance learning (ODL) teacher professional development programme through the Unit of Open Distance Learning (UoDL) at the North-West University at the Potchefstroom Campus. They were all established Mathematics teachers at semi-rural schools in the North-West Province, South Africa, and enrolled for a BEd Honours programme. The design of the application was based on RME principles: (i) guided reinvention (or progressive mathematisation); (ii) emergent modelling; and (iii) didactical phenomenology (Andresen, 2007). The process of guided reinvention began with a real-life problem which was then mathematised (Gravemeijer and Doorman, 1999). The aim with the app was to guide these teacher students to become comfortable with using technology in teaching and learning, as well as to enable them to interact with their learners on RME.

3.1 Creating the app

Software engineering (SWE) is the application of engineering to the design, development, implementation, testing and maintenance of software in a systematic method. The objective of software engineering is to produce software systems to customers in a cost effective way. Once installed these systems should display characteristics such as efficiency, reliability, maintainability, robustness, portability and so on (Sommerville, 2016). The software process is a set of activities and associate results which produce a software product. Software specification, development, validation and evolution are fundamental process activities common to all software processes.

Software development models are processes or methodologies used for the development of software projects. There are many development models that have been developed in order to achieve different objectives. The models specify the various stages of the process and the order in which they are carried out (Sommerville, 2016). Examples of software development models are: Evolutionary Prototyping Model; Spiral Method (SDM); Iterative and Incremental Method; Extreme programming (Agile development); Waterfall model; Prototype model; Rapid application development model (RAD) and so on (Whitten and Bentley, 2007). Choosing the right model for developing a software product or application is very important as the model determine where and when the development and testing processes are carried out.

For the development of our app, which we name Financial Maths App, we decided to use the Prototype Model because of the advantages that this model offer: Users are actively involved in the development; Since a working model of the system is provided, the users get a better understanding of the system being developed; Errors can be detected much earlier; Rapid user feedback is available leading to better solutions; Missing functionality can be identified easily; and Confusing or difficult functions can be identified (Mohammed et al., 2010). The basic idea is that instead of freezing the requirements (as required by many other models) before a design or coding can proceed, a prototype is built to understand the requirements based on the currently known requirements. By using this prototype, the client can get an “actual feel” of the system, since the interactions with the prototype can enable the client to better understand the requirements of the desired system. The prototype is usually not a complete system and many of the details are not built into the prototype. The goal is to provide a system with overall functionality. Figure 1 depicts the phases in the development of a prototype.
3.2 Creating the app

**Background.** While the first author of this paper was the designer of the app, the second author was the content specialist and also responsible for the various design documents, and the third author was the expert on the use of technology in teaching and learning. Together they formed a tight project team. They obtained ethics clearance for this research from the Ethics Committee of the North-West University (NWU-HS-2014-0267).

**Requirement (Step 1).** The first step in creating an app was to develop a clearly defined purpose for the mobile app: we had to determine what the app should be able to do; what its primary appeal would be; which concrete problem it was going to address; and what part of life it aimed to improve. Detail design documents were created which outlined the standards, planning design, development, and ongoing evaluation of the project (Fleisch and Schöer, 2014).

**Quick Design (Step 2).** Next the foundation of the user interface was laid. This step visually conceptualized the main features and a rough layout and structure of the app. Sketches for the proposed layout and structure of the app were drawn which assisted the team to understand the journey better Figure 2 is an example of such a sketch.

**Building Prototype (Step 3).** At this stage all the ideas and features culminated as a clear picture of the structure and a storyboard for the project was created. The storyboard provided a road map which illustrated the connections between the different screens and how the user could navigate through the app. The storyboard formed the foundation for the first version of the prototype.

**Customer Evaluation (Step 4).** The next step involved the testing of the prototype. Friends, family, colleagues, and experts all helped to review the prototype. They were requested to test run the app and give sincere feedback and identify flaws and dead-end links. If possible to monitor how they used the app, one should take note of their actions as these would provide important feedback for user interface (UI) and user experience (UX) evaluation (Molich and Nielsen, 1990). Based on their feedback, the prototype was modified. The aim was to finally specify the app concept before going into the design process. For the
Financial Maths app, the content author tested the app with two of her Mathematics colleagues who are Mathematics lecturers, as well as with a RME expert.

Refining Prototype (Step 5). Next, individual screen content were designed. The task was to create high-resolution versions of the prototype. All comments from the prototype testers were included in order to design the most suitable user interface. With the screen designs completed and implemented, the actual app concept was complete, all the graphics were inserted, and all text was signed off—the actual design was now implemented and made clickable.

Repeat (Step 2 to 5). The next step was to test the full design once more and collect as much feedback as possible from a variety of users. The new ideas and comments were used to refine the app. A consistent look and feel of the layout was assured and we ensured that it would perform reliably on different devices.

Deployment (Step 6). As the vast majority of the intended students used Android devices (Dahlstrom et al., 2016), the brief was to develop the Financial Maths app for Android devices (smart phones and tablets). The Financial Maths app was consequently installed on Android devices and tested for functionality in a live environment.

4. USABILITY OF THE APP

4.1 The user interface

Figure 1 illustrates two scenarios that are realistic and relevant to students at school, from which the concepts of simple and compound interest could develop. Students are not expected to reinvent all the content themselves, and should be guided by the teacher who allows them the opportunity to reflect on their invented strategies (Gravemeijer and Doorman, 1999). Drijvers et al. (2013) suggest that guidance from the teacher will help the progression in a sensible manner, as is suggested in Figure 3.

Emergent modelling refers to the development of models from the student’s activity which leads to the emergence of formal Mathematics (Gravemeijer and Doorman, 1999). The use of models is encouraged as a bridge between what is abstract to students and what is real (Dolk et al., 2002). Figure 4 illustrates how the use of models has been encouraged in the app. The models too are grounded in the contextual problem and are not derived from the intended Mathematics (Gravemeijer, 1999). The last screenshot in Figure 4 illustrates that students are in various instances given three opportunities to attempt to develop their own strategies to solve a problem before a hint is given.
The third principle that was incorporated in the design of the app was didactical phenomenology, which deals with the idea of how mathematical structures can assist in organising phenomena in real life (Zulkardi, 2000). Students are confronted with situations that need to be organised, and in that way students can build concepts (Bakker et al., 2003). The phenomena of personal finances, hire-purchase and interest rates are relevant real-life notions that can be structured with mathematical content (Figure 5).

4.2 General usability of the app

The initial design document provided the design team with a broad idea of the content of the app. In the drafts to follow, more particulars are given with regard to the detail of when hints and tips should appear; how many attempts students can make on a solution before receiving help; and words of encouragement when the solutions are correctly worked out. Molich and Nielsen (1990) are of the opinion that general usability evaluations should comprise not more than ten members, and the design team followed this suggestion. The three team members perused and tested the first two prototypes and suggested changes in terms of usability. An RME expert evaluated the third prototype of the app and focused specifically on the inclusion of the RME principles. His evaluation revealed that all the principles of RME were sufficiently addressed in the app and that it should achieve the purpose for which it was designed, namely to make
teachers’ teaching of Mathematics, and learners’ learning experiences more realistic, relevant and experientially real. He suggested that the app be thoroughly tested before being released for student use.

Two more experts in the field of Mathematics education tested the app. Their main suggestion for improving the app was to make the problem situation more visible at the start of the app:

*Put something in that sets the scenario more clearly. The start of the app is too vague.*

Their evaluation also included comments on why they felt the app was suited to the purpose for which it was created:

*It works very well because all the steps are clearly shown. It will help the teachers to teach their learners to follow logical steps in their calculations.*

The app included an activity that clearly showed the intertwining of the concepts of compound and simple interest, a key characteristic of RME (Widjaja and Heck, 2003). The Mathematics education experts found this appropriate and necessary:

*I like this very much. By including this comparison of concepts you can see wow, it’s quicker to use the compound interest formula, and yet you still get the same answer as when repeating the simple interest formula.*

They also suggested that the app be extended to other content areas and that it be made available to a wider range of teachers.

5. CONCLUSIONS AND RECOMMENDATIONS

The design of this app has the potential to be extended into a larger project where a variety of problem content areas in Mathematics, at different grade levels, could be addressed. These apps could be made available to any Mathematics teacher who needs assistance with both content as well as the notion of incorporating relevant, real life contexts in their Mathematics teaching.

A comment made by a Mathematics education specialist relates to the need for the development of users of such apps in terms of the integration of technology into their every teaching and learning:

*We had a bigger problem working the phone that doing the sums. Let’s hope that the students that will be using this app are comfortable with the technology.*

Although one of the points of criticism from the subject experts was that the problem scenario was not well articulated, the design team is of the opinion that a more graphic approach would work better. The context and content should be presented with the aid of more graphics and less words.

ACKNOWLEDGEMENT

We would like to thank the National Research Foundation of South Africa for in part supporting this work. Any opinion, findings and conclusions or recommendations expressed in this material are those of the authors and therefore the NRF does not accept any liability in regard thereto.

Thank you also to the teacher-students who shared their needs for the app with us for their patience, dedication and willingness to participate in the study and learn with us.

REFERENCES


Dear Author

We are pleased to inform you that your submission to the 13th International Conference on Mobile Learning (ML 2017) has been accepted as a "Full Paper".

Please, make the suggested corrections to your paper (see details below), use the correct format available at http://mlearning-conf.org/submissions/ (very important: if this format is not followed we cannot accept your contribution and it won't be published in the proceedings). Make sure that your final submission has the number of pages allowed for this category which is 8 pages (additional pages up to 4 will be charged as specified in the registration form). Also note that your final submission must be a WORD file since proceedings are produced in WORD.

Also, login to your author area available at http://www.conf-system.org/confman_ml2017/author_menu.asp with your login and password, and

1 - submit the final version - in word or rtf version please until 9 December 2016 (please submit from your author area link only),
2 - access the copyright form, fill it out and send it in order for your contribution to be published (until 9 December 2016),
3 - print an invitation letter (if required) for you or any of your co-authors,
4 - register for the conference (deadline for this procedure is also 9 December 2016 - if not registered the paper won't be published in the proceedings. This deadline also corresponds to the early registration rates for this call - select the early registration option from the rates part of the registration form),
5 - View hotel information and book hotel at http://mlearning-conf.org/venuehotel-info/,
6 - Check the guidelines for presenters available at http://mlearning-conf.org/guidelines/.

Hope to see you in Budapest, Hungary, during 10 - 12 April 2017.

For any information please contact us. Thank you.

Best regards,

Inmaculada Arnedillo Sánchez, Trinity College Dublin, Ireland
Program Chair

Pedro Isaias, University of Queensland, Australia
Conference Chair

NOTE: This e-mail is being sent to all co-authors of this submission.

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Please consider the following data for your final submission (using the link above):

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CERTIFICATE
issued on 17 November 2016

I hereby declare that I have edited the language of the PhD thesis

*Guidelines for effective technology facilitation of Realistic Mathematics Education to enhance teaching practice*

by

DJ Laubscher, student number 10218343

submitted for the degree

*Doctor Philosophiae* in Mathematics Education

at the Potchefstroom Campus of the North-West University

*The responsibility to accept recommendations and effect changes remains with the author.*

H C Sieberhagen
SATI no 1001489
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Potchefstroom 17 November 2016
Hermeneutic Unit: Systematic literature review relating to the use of ICT to facilitate the principles of realistic mathematics education to enhance teaching practice

Author(s): Super

Addendum 9

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Author(s): Super

Systematic literature review relating to the use of ICT to facilitate the principles of realistic mathematics education to enhance teaching practice

Abstract

1

4

The main point in Ackermann's description of Papert's view is: diving into situations rather than construction of internal stability whereas Papert is more interested in the dynamics of adaptation as knowledge as a personal experience to be constructed. Further, they both acknowledge as constructivists who see children as the builders of their own knowledge as a personal experience to be constructed. Further, they both acknowledge as constructivists who see children as the builders of their own knowledge as a personal experience to be constructed.

Jean Piaget and Seymour Papert

To facilitate cognitive growth, Edith Ackermann presents the idea of a bi-directional interplay between the observer and the student's construct - Changes within the pairs of perspective should be recognisable for the teacher (or any student's construct designate of all the changes of perspective and all the changes between common denominator for the important elements in focus of my interest. They gave inspiration could promote the student's learning way - Serve as a contribution to math education theory - Identify, articulate and conceptualise the participants' shared experiences of improved learning - Be a basis for new learning; laptops; differential equations; Realistic mathematics education (RME)

they were the basis of four small-scale teaching experiments. The teaching experiments, being part of a development project in upper secondary mathematics, encompassed introducing the use of CAS in mathematics, chemistry and physics. Teaching with CAS would make it possible for pupils to focus on the ideas, beliefs, and constraints for their learning; laptops; differential equations; Realistic mathematics education (RME)

2.1. A dynamical approach to concept formation

Gravemeijer's four level model and iii) the French theory of Instrumental Genesis. Ackermann, ii) vertical and horizontal mathematising in the RME sense realised in Koeno

that combines main heuristics of Seymour Papert and Jean Piaget, introduced by Edith

Learning allows the researcher to inquire the students' mathematical realities. These realities are called students' representations, referred to in the definition, are presented in a later paragraph in this paper. Many researchers expressed a shared experience of improved learning: in the interviews, a number of students and

In Denmark, a recent reform of the structure and the curriculum in upper secondary school learning; laptops; differential equations; Realistic mathematics education (RME)

2

I was employed at the Danish University of Education to do the research in part A of the world Class project. Part A of the development project encompassed introducing the use of CAS in mathematics, chemistry and physics. Teaching with CAS would make it possible for pupils to focus on the ideas, beliefs, and constraints for their learning; laptops; differential equations; Realistic mathematics education (RME)

In Wittmann (1998) and Lesh & Sriraman (2005), that mathematics education is a design activity, and the teachers as designers have the responsibility to design learning activities, for teachers to aim at in their secondary mathematics teachers. The other main aim was to draw on the project's experiences for theory development within a framework based on Realistic Mathematics Education (RME) and natural sciences. The project included four small-scale teaching experiments. The teaching experiments, being part of a development project in upper secondary mathematics, encompassed introducing the use of CAS in mathematics, chemistry and physics. Teaching with CAS would make it possible for pupils to focus on the ideas, beliefs, and constraints for their learning; laptops; differential equations; Realistic mathematics education (RME)

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Hermeneutic Unit: Systematic literature review relating to the use of IC...
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includes talk, explanations and negotiations, some texts written by the students or the by teacher,
conception in question as well.
words, of course, can still be learned by root. Nevertheless, in the notion of flexibility such
capability to handle the content 'in his or her own words'. Standard phrases resembling own
version, adapted to the computer or calculator in question. Changes to computer language span
The changes to natural language in many cases cover complex processes of interpretation and
language when technical terms are used, for example in group discussions.
standard phrases are considered natural language. Natural language can overlap with formal
mediated in computer language: graphs, formal expressions and natural language can all be
expressed in technical language too. In some cases, further, the software allows simultaneously
subsequently, I carried out an empirical study which aimed to
4. Episode from a case study
of the reactants were equal. But what happens, if \[ A \] does not equal \[ B \] from the beginning, or
We have inquired second order reactions in the simple cases, where the initial concentrations
the model (1.8) is a general application of (1.1) to the case of a second order irreversible
Therefore, (1.8) can give both perspectives on the equation, depending on which of the two
the actual experiment in the task.
and explain, what this means in practice TMME, vol4, no.2, p.243
Based on the text we state the following:
the reaction starts. The rate constant \( k \) is \( 1 \).
\[
\frac{dt}{dx} = k \cdot a \cdot x \cdot x - b \cdot x \cdot x
\]
\[
(1.7) = -\frac{dt}{k} = x \cdot x - b \cdot x \cdot x
\]
\[
(1.6) = x \cdot x = 2
\]
\[
\frac{a}{k} = \frac{b \cdot x}{x \cdot x}
\]
\[
(1.5) = \frac{d}{dx} \left( x \cdot x - b \cdot x \cdot x \right) = \frac{dt}{dx}
\]
\[
(1.4) = \frac{d}{dx} = \frac{dt}{dx} = \frac{a \cdot x \cdot x - b \cdot x \cdot x}{k}
\]
\[
(1.3) = \frac{dt}{dx} = \frac{a \cdot x \cdot x - b \cdot x \cdot x}{k}
\]
\[
(1.2) = \frac{dx}{dt} = \frac{b \cdot x}{x \cdot x}
\]
\[
(1.1) = \frac{dx}{dt} = \frac{b \cdot x}{x \cdot x}
\]
\[
\frac{1}{x} = \frac{1}{2}
\]
\[
1 = 2
\]
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k = 1
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a0 = 2
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b0 = 1
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a0 = 2
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Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

1. What is new?

The case illustrates how flexibility intends to serve as a tool for clarification: The case's task novel idea beyond the construction of flexibility is to focus on the dynamics as a common representation. The relation between the levels in Gravemeijer's model is another example. The elaborated description of the single elements of flexibility would be the next step. The issue of visualisation, for example, is included in flexibility in terms of change to graphic representations. According to the definition of flexibility, the individual student's flexibility of activities which promote the student's actual work with mathematics in an observable way. The summarises, connects and simplifies key elements of well established and acknowledged theory. terms already, has to be justified. One important argument is that the introduction of flexibility... passed to and fro a model of perspective and further interchanges in this case.

2. Does flexibility keep the promises?

The students explicitly interpreted the actual values of the roots as concentrations. This situation illustrates a tool perspective on the solving of quadratic equation... of and model for perspectives were realised on the relation, modelled by the differential equation.

3. What is left?

Therefore, in terms of flexibility, they encourage to changes between model for and model of perspective. This situation illustrated a tool perspective on the solving of quadratic equation. This problem was set in a model for perspective... form a report on the instructional process through the collected data. At the end of task 3, group 9 divided into parts that took the model of perspective and other parts that took a model for perspective, according to the question of the task. The correct approach to the task 3 was: the change of model for perspective and model of perspective (referential level) to the concentrations in the reality perspective. Later on, the task 3 was interpreted by the teacher, referring to theory: the changes between model for perspective and model of perspective (referential level) to the concentrations in the reality perspective. This was the change of model for perspective and model of perspective. The equilibrium points were seen in a model of perspective. The students explicitly interpreted the actual values of the roots as concentrations. This situation illustrated a tool perspective on the solving of quadratic equation.

4. Conclusion of case 8

During the complete case, changes between reality and model perspectives and between model for perspective and model of perspective were in this case realised as changes between model for perspective and model of perspective.

References: page 209 in diploma (TME), ed. a. p. 148

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5.3. What is left?

Therefore, in terms of flexibility, they encourage to changes between model for and model of perspective. This situation illustrated a tool perspective on the solving of quadratic equation.
Tool use and symbolic construction of meaning within the construct flexibility. In this sense, instructional designers should take into account how students might act and reason with the tools as they participate in a sequence of mathematical practices. In K. Gravemeijer, R. Lehrer et.al. (Eds). Symbolizing, Modeling and Tool use in Mathematics Education (pp. 191-219). New York: Lawrence Erlbaum Associates.


As a result, our research goal is to develop a computer tool that supports students in developing and evolving different perspectives on the function concept, and to test how such a tool can affect the learning of students. This goal is related to the underlying theoretical assumptions that students' cognitive development is a process of constructing and reconstructing their understanding of the world through interaction with their environment. In this process, students actively construct knowledge by engaging in mathematical practices that involve reasoning, problem solving, and communication. These practices are supported by the use of tools and artifacts, such as computer tools, to mediate and extend their thinking and reasoning.

The project is supported by the Netherlands Organisation for Scientific Research (NWO) with grant number 400-03-006. The project's objectives are to (1) develop a computer tool that supports students in developing and evolving different perspectives on the function concept, and (2) test how such a tool can affect the learning of students. To achieve these objectives, the project will involve a collaboration between researchers and teachers to design and implement the computer tool and conduct a classroom-based study to evaluate its effectiveness in supporting students' learning.

The project will involve the following phases:

1. Design phase: The design of the computer tool will be based on an analysis of students' cognitive development and the function concept. This analysis will be informed by previous research on students' understanding of the function concept and the cognitive processes involved in its development.

2. Implementation phase: The computer tool will be implemented in a classroom setting and the effectiveness of the tool in supporting students' learning will be evaluated through a classroom-based study. The study will involve the use of pre- and post-tests to assess students' understanding of the function concept, as well as observations of students' mathematical practices during the use of the computer tool.

3. Reflection phase: The results of the study will be analyzed and the effectiveness of the computer tool in supporting students' learning will be evaluated. The findings of the study will be used to refine and improve the design of the computer tool.

The project is expected to contribute to the field of mathematics education by providing new insights into the role of computer tools in supporting students' cognitive development and the function concept.
The investigations took place in three classes of three different schools in the Netherlands. The video recordings were made with a camera tool. These screen videos were imported in ATLAS.ti. Initially, the clipping of the screen videos of three pairs of students working with the computer were captured (6 Video recordings were made of classroom teaching and group work (17 hours), and were analyzed with a design research method of iterative phases of instructional design, success of digital technology in mathematics education include the design of the digital tool and corresponding tasks exploiting the tool's pedagogical potential, the role of the teacher and the educational context.

We started the analysis by watching and annotating the work of a pair of students and comparison of argumentations. We described each exercise-clip with the analyses and coding of the data using the video analysis tool ATLAS.ti.

The result of this second analysis offered evidence for the conjecture of a form-function-shift in the students' reasoning with chains of calculations in the computer tool. During the coding we also observed that with the first activity students sometimes tried to calculate-routines turned into chain signified organizing a dependency-relationship. Calculation-routines turned into a form-function-shift (Saxe, 2002) for describing what happened in the learning process upon the idea of emergent modeling, which is a characteristic of realistic mathematics education. Moreover, in the classroom learning processes, we noticed that students initially inscriptions that were not as precise as the notions aimed at. This seems similar to the construction and modification of arrow chains, graphs and tables, and the generation of chain as a record for calculating a specific value, while the activity at the end of the PNA, 8(1), 1-20.

Further research is needed to investigate what makes a mathematical tool meaningful and instrument-shifting shift with the creation of instrumental genesis is able to better understand the fundamental emerging of instrumental genesis is able to better understand the fundamental emerging of digital technology, which tools and materials did not exist beforehand. Our research pointed to the importance of digital technology in mathematics education. In the position statement claims that "Technology is necessary for all mathematics. Mathematical Thinking and Learning 1(2), 155-177. Gravemeijer, K. (1999). How emergent models may foster the constitution of formal reasoning about input-output-dependencies, and that this reasoning would change to a form-function-shift (Saxe, 2002) for describing what happened in the learning process upon the idea of emergent modeling, which is a characteristic of realistic mathematics education. Moreover, in the classroom learning processes, we noticed that students initially inscriptions that were not as precise as the notions aimed at. This seems similar to the construction and modification of arrow chains, graphs and tables, and the generation of chain as a record for calculating a specific value, while the activity at the end of the learning process (Saxe, 2002) for describing what happened in the learning process upon the idea of emergent modeling, which is a characteristic of realistic mathematics education. Moreover, in the classroom learning processes, we noticed that students initially inscriptions that were not as precise as the notions aimed at. This seems similar to the construction and modification of arrow chains, graphs and tables, and the generation of chain as a record for calculating a specific value, while the activity at the end of the
So did technology work in this case? Yes, it did at the level of learning: The and the character of the curriculum. In the light of that time’s thinking on the role transformation, data collection and analysis, visualisation, and checking. The results show that the teacher was crucial in establishing and reinforcing these would not consider the digital technology available in 1988 as very sophisticated, its approach in that its results form a first “proof of existence”: indeed, it seems about their work and helped them to concentrate on the global problem-solving classroom in particular.

The digital technology allowed for a “concept-first” approach, which means that calculus concepts were extensively taught, using computer algebra, table tools and graphing tools that were used for concept mathematics education. The study addresses the resequencing of a calculus considered as one of the first leading studies into the use of digital technology in

...continue reading...
The discussion of the studies addressed cannot be but somewhat superficial in the current state of research. Technologies are not described in detail, and some of the findings are based on a limited number of cases. Nevertheless, some general conclusions can be drawn. Teachers can engage in a process of professional development. The third and final factor to identify is that from optimism on student learning in the early studies towards more realistic views. The last factor concerns the role of the teacher, which is crucial in Cases 2 and 3. Finally, the factors concern the educational context, which includes the design of the digital technology involved, the role of the teacher, and the educational context. The factors have been identified as important in the successful integration of digital technology in education. A second lesson to learn for us as researchers is the importance of understanding the educational context. It is not enough to study the use of digital technology without considering the context in which it is used. A third lesson is that the factors identified in this study are not mutually exclusive. They are interrelated and interact with each other. A fourth lesson is that the factors identified in this study are not limited to the context of mathematics education. The factors are likely to be relevant in other domains of education as well. The factors identified in this study are important for the design and implementation of digital technology in education. They can be used to guide the development and use of digital technology in education. The factors can also be used to evaluate the effectiveness of the integration of digital technology in education. Finally, the factors identified in this study can be used to support the professional development of teachers. The factors can be used to guide the design of professional development activities. The factors can also be used to evaluate the effectiveness of professional development activities. The factors can be used to support the implementation of digital technology in education.
As an example of the design of digital tasks for algebra, we consider the work by Bokhove, available at ..., units go beyond procedural practice and also focus on the development of symbol sense and strategic skills (Bokhove & ... levels of mathematical activity (Gravemeijer, 1994). For the task designer, the challenge is to find suitable situations that ask for the development of such models, and allow for a process of progressive abstraction.

According to the emergent modeling perspective, a model may play different roles during different phases of activity. In the beginning, it may serve as a tool for guiding the construction of a model of the situation. Later, it may function as a tool for testing the adequacy of the model. Finally, it may function as a tool for communicating the model to others. In this way, the model is continually being refined and improved.

In this short paper, we set out to investigate the application of the RME principles of guided reinvention, didactical phenomenology, and emergent modeling (Freudenthal, 1973; Gravemeijer, 1994; Van den Heuvel-Panhuizen, 1996). The case study reported here focuses on the design of one digital task to teach students how to solve a system of linear equations. The task is based on the model of the didactical situation, which is a model of the situation that the student is expected to build. The model is a tool for guiding the student's thinking and for facilitating the construction of the model of the situation. The model is also a tool for testing the adequacy of the model. Finally, the model is a tool for communicating the model to others.

Digital Tasks for Geometry

In the field of geometry, digital tasks can be used to support the development of geometric thinking. A digital task is a problem that is presented in a digital environment and that is designed to support the development of geometric thinking. The digital task is presented in a digital environment, which is a model of the environment in which the student is expected to build. The model is a tool for guiding the student's thinking and for facilitating the construction of the model of the environment. The model is also a tool for testing the adequacy of the model. Finally, the model is a tool for communicating the model to others.

Conclusion

In the case of this online module, classroom observations show that attention needs to be paid to students' and teachers' practical work. The use of digital tasks and tools is powerful but it may also be demanding and initially complex to novice users. To support the development of such tasks and tools, it is necessary to focus on the design of digital tasks and tools that are suitable for the development of geometric thinking.

The authors thank the Freudenthal Institute for Science and Mathematics Education and the Freudenthal Group for their support. The paper is an extended version of a contribution to the 8th Conference of the International Group for the Psychology of Mathematics Education (2016). The authors thank the Freudenthal Institute for Science and Mathematics Education and the Freudenthal Group for their support. The paper is an extended version of a contribution to the 8th Conference of the International Group for the Psychology of Mathematics Education (2016).
Doorman, M., Drijvers, P., Gravemeijer, K., Boon, P., & Reed, H. (2012). Tool use and the development of the function concept: Making connections between informal strategies and algebraic expressions via graphic (or geometrical) illustration of functions on the screen from one of "passive performance" to that of "active investigation." Visual form of algebra instruction. The class conversation at the beginning of this exploration can be acquired through the graphics calculator. Inventory and classification of such an approach has led to the development of a tool for further development: a tool for investigating mathematical distribution and composition. Finally, the use of the tool designed is such that emerging models need to be expressed by the digital text available. For example, by illustrating sequences or transformations and making the digital tools clear to the reader, systems are deduced. This is a tool that, for example, is to be used to examine the text. The results of this section will lead to the next section.

How do these general starting points of realistic mathematics education translate into the use of ICT in mathematics education? What is the potential of this new technology? Exploring the potential of the graphics calculator is addressed. The concept of "reform" in education can be integrated into mathematics education? A high degree of student input. A variety of solution strategies. Use of informal strategies and informal knowledge.

The first hypothesis is, therefore:

l Use of the graphics calculator in instructional sequences:

l The first hypothesis is, therefore:

l Use of informal strategies and informal knowledge.

l A high degree of student input.

l A variety of solution strategies.

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Doorman, M., Drijvers, P., Gravemeijer, K., Boon, P., & Reed, H. (2012). Tool use and the development of the function concept: Making connections between informal strategies and algebraic expressions via graphic (or geometrical) illustration of functions on the screen from one of "passive performance" to that of "active investigation." Visual form of algebra instruction. The class conversation at the beginning of this exploration can be acquired through the graphics calculator. Inventory and classification of such an approach has led to the development of a tool for further development: a tool for investigating mathematical distribution and composition. Finally, the use of the tool designed is such that emerging models need to be expressed by the digital text available. For example, by illustrating sequences or transformations and making the digital tools clear to the reader, systems are deduced. This is a tool that, for example, is to be used to examine the text. The results of this section will lead to the next section.

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Figure 1.
The project was conducted in two stages, beginning with the building of the library of prestructured graphical designs. Two of these designs were chosen to be included in the first stage, the first of which was a spiral with the equation $y(t) = 2sint + f sin (4t + \pi)$. The second design was a cardioid, the equation of which was $x(t) = 2cost - 1 + a cos (2t + \pi)$. The cardioid was chosen because the effect of the parameter $a$ on the shape of the cardioid could be observed. In the second stage, the students were given the task of creating their own designs. They were given the freedom to choose any parameter in the equation and were encouraged to experiment with different values.

The students were divided into groups of three, each group having access to a graphics calculator. The teachers were present during the entire process, providing guidance and suggesting possible designs. The students were asked to create a design that would demonstrate the effect of the parameter $a$ on the shape of the cardioid.

The students were encouraged to use the graphics calculator to create their designs, and they were given the opportunity to share their work with the class. The teachers were also present during the presentation, providing feedback and suggesting possible improvements.

The project was evaluated based on the students' ability to create a design that demonstrated the effect of the parameter $a$ on the shape of the cardioid. The students were also evaluated on their ability to use the graphics calculator effectively and to present their work clearly.

The project was successful in demonstrating the potential of the graphics calculator in teaching mathematics. The students were able to create designs that demonstrated the effect of the parameter $a$ on the shape of the cardioid, and they were also able to present their work clearly.

The project also had the added benefit of providing the teachers with a tool to use in their teaching. The graphics calculator allowed the teachers to create designs that demonstrated the effect of the parameter $a$ on the shape of the cardioid, and they were also able to present their work clearly.

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LEARNING FROM EXPERIENCE AND CONCLUSION
Let us place this study of the present moment at the accompanying overview. With the computer tool sorely needed in the classroom, teaching and learning have become more dynamic. That is the first step towards a more professional involvement in the educational process. The teacher must take an active role. In the past, the teacher has been the one to make decisions. In the future, the teacher will make decisions together with the students. This is the path to a more participatory learning process.

The results of the study 166
1. Introduction to the problem 161
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4. The results of the study 166
5. The development of an RME-based geometry course for VW0 Math A and Math B 167
6. Reflection and conclusions 174

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Methods 161
The aim of this study was to develop and implement a valid, practical, and effective RME-based geometry course for VW0 Math A and Math B. The development of this course was based on the following assumptions:

1. The curriculum should be based on the RME approach:
   - Mathematics should be taught as a coherent whole, including its connections with other disciplines.
   - Mathematics should be taught as a meaningful whole.
   - Mathematics should be taught as a dynamic whole.

2. The course should be based on the following principles:
   - The course should be based on the RME approach:
     - Mathematics should be taught as a coherent whole, including its connections with other disciplines.
     - Mathematics should be taught as a meaningful whole.
     - Mathematics should be taught as a dynamic whole.

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     - Mathematics should be taught as a meaningful whole.
     - Mathematics should be taught as a dynamic whole.

10. The course should be based on the following principles:
    - Mathematics should be taught as a coherent whole, including its connections with other disciplines.
    - Mathematics should be taught as a meaningful whole.
    - Mathematics should be taught as a dynamic whole.
researchers direct their attention to developing instructional sequences in learning mathematics. Gravemeijer (1999; and see also Gravemeijer & Cobb, 2006) states that in this approach knowledge from prior research in the design process and fine-tune educational innovations. 164 Related to this, Nieveen (1997) and Van den Akker (1999) mentioned three important activities in design research are its cyclic nature (of analysis design, development, and evaluation of the final product. Throughout all these activities, a systematic reflection on the results of the study of design research is required. In the course of designing an educational environment, the design researcher needs to consider the following questions: 165

- What are the characteristics of a valid, practical, and effective RME-based geometry course for teaching geometry at grade 4 in Indonesian primary school?
- How can we improve the instructional approach to mathematics education in Indonesia primary school which will provide a high quality of mathematics education for students.

The general goals of mathematics education in Indonesia primary school have been realized; however, many problems have been discovered. 166

- Insufficient pre-service mathematics teachers' knowledge and understanding of RME.
- Low mathematics achievement in primary schools.
- The majority of mathematics education in Indonesia primary school is still taught using traditional methods such as memorization and practice without understanding the material.

To answer these questions, we conducted a four-year experimental research in three Indonesian primary schools where the students' mathematics achievement was low. The experimental design was a single-subject design with three cycles. The cycles of the thought and instruction experiment described above indicate the activities of the research: 167

1. Preparation phase (Front-end analysis, prototyping stage).
2. Implementation phase (Implementation process).
3. Evaluation phase (Pupil learning outcomes and evaluating the RME-based geometry course).

The purpose of front-end analysis is to get a picture of the starting point and the potential end points. The front-end analysis process starts with context and problem analysis. The context and problem analysis is the process of identifying the target group, the problems they face, the limitations they have, and the expected benefits. The context and problem analysis are crucial in the design research because they provide a guide for the design and development of the final product. 168

In this study, we focus on the implementation process because we believe that this process is the most important phase in design research. The implementation process is the stage where the design research is transformed into a product that can be used in practice. The implementation process is divided into three stages: 169

- The implementation process (how teachers teach in the classrooms).
- The evaluation process (how well the RME-based geometry course works).
- The improvement process (how to improve the RME-based geometry course).

This study built upon two “schools of thought” of design research. The first one emerges in the context of more general design and development questions (see Van den Akker, 1999; Van den Akker & Gravemeijer, 1996). The second one is the development of educational materials that are based on RME. This study was designed to be the latter type of design research. The cycles of the thought and instruction experiments were designed to be a series of qualitative investigations to understand students' learning and teaching process. 170

The results of the study are divided into two parts: (1) the characteristics of RME-based instruction in Indonesian primary schools; and (2) the effectiveness of the RME-based geometry course in Indonesian primary schools. The results of the study are analyzed using qualitative methods, such as content analysis, case study, observation, and interview. 171

In the results of the study, we describe the characteristics of RME-based instruction in Indonesian primary schools. These characteristics include the following elements: 172

- The use of real-life contexts in learning mathematics.
- The use of problem-solving activities in learning mathematics.
- The use of group work and discussion in learning mathematics.
- The use of technology in learning mathematics.

In the results of the study, we also describe the effectiveness of the RME-based geometry course in Indonesian primary schools. The effectiveness of the course is measured by the following elements: 173

- The improvement of students' mathematics achievement.
- The improvement of students' problem-solving skills.
- The improvement of students' attitudes towards mathematics.
- The improvement of students' motivation to learn mathematics.

In the results of the study, we also discuss the implications of the study for the development of RME-based geometry course in Indonesian primary schools. The implications of the study include the following elements: 174

- The need for more research on RME-based instruction in Indonesian primary schools.
- The need for more research on the effectiveness of RME-based geometry course in Indonesian primary schools.
- The need for more research on the characteristics of RME-based instruction in Indonesian primary schools.

The study shows that RME-based instruction can be effective in improving students' mathematics achievement in Indonesian primary schools. The results of the study indicate that RME-based instruction can be a viable alternative to traditional mathematics instruction in Indonesian primary schools. The results of the study also show that RME-based instruction can be used to develop a high quality of mathematics education for students. The results of the study also show that RME-based instruction can be used to develop a high quality of mathematics education for students that are based on RME. The results of the study also show that RME-based instruction can be used to develop a high quality of mathematics education for students that are based on RME in Indonesian primary schools.
Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

The topic Area and Perimeter at Grade 4 in Indonesian primary schools? What are the characteristics of a valid RME-based geometry course for learning and teaching

This activity was guided by the next research question:

- Does the RME-based geometry course reflect the RME's teaching and learning principles?

It was important to determine that the draft course would fit not only the Indonesian curriculum, but also the context in which the teachers and students work. The term RME (Realistic Mathematics Education) is used to describe a teaching and learning approach that has been developed in The Netherlands (see Gravemeijer, 1994a; Veldkamp & Gravemeijer, 1998). RME is based on the belief that students' prior experiences and knowledge can be used as a starting point for teaching mathematics. In RME, the focus is on the development of mathematical concepts through problem-solving activities that are relevant and meaningful to students. The RME approach emphasizes the following principles:

1. **Guided reinvention:** Students are encouraged to construct their own mathematical knowledge by solving problems in a meaningful context. This is done by starting with students' prior knowledge and gradually leading them to discover new mathematical concepts.
2. **Didactical phenomenology:** The teaching and learning process is guided by the development of mathematical concepts as they are naturally found in the real world. This involves selecting situations that are relevant to students' everyday experiences and using them as a basis for teaching mathematics.
3. **Contextual problems:** Students are presented with problems that are situated in real-life contexts, allowing them to apply their mathematical knowledge in practical situations.
4. **Formalization:** Once students have developed a tentative understanding of a concept, they are guided to formalize it. This involves moving from informal, intuitive understandings to more abstract, formal representations.
5. **Interactivity:** The learning process is characterized by interactions between students and teachers, as well as between students themselves. These interactions help to enrich the learning experience and promote deeper understanding.
6. **Reconstruction:** Students are encouraged to reconstruct their understanding of mathematical concepts through ongoing reflection and discussion. This helps to solidify their knowledge and improve their problem-solving skills.

Research with children also showed that the RME approach is effective in improving students' mathematical understanding. For example, research has shown that RME-based geometry courses for learning and teaching the topic Area and Perimeter were effective in helping students develop a deep understanding of the concepts. In particular, the RME approach was found to be effective in helping students:

- **Understand mathematical concepts:** Students were able to develop a deeper understanding of mathematical concepts such as area and perimeter. This was achieved through the use of concrete materials and real-life situations.
- **Apply mathematical concepts:** Students were able to apply their understanding of area and perimeter to solve problems in various contexts. This was achieved through the use of contextual problems that were relevant to students' everyday experiences.
- **Develop problem-solving skills:** Students were able to develop their problem-solving skills through the use of open-ended problems and real-life situations.
- **Enhance mathematical reasoning:** Students were able to enhance their mathematical reasoning through discussions and interactions with their peers and teachers.

To test the effectiveness of the RME-based geometry course, the following aspects were assessed:

- **Contextual problems:** The contextual problems were assessed to determine whether they were relevant and meaningful to students. This was done by conducting interviews with teachers and students.
- **Teacher guide:** The teacher guide was assessed to determine whether it was easy to use and whether it provided adequate guidance for teachers.
- **Student book:** The student book was assessed to determine whether it was easy to use and whether it provided adequate support for students.

In conclusion, the RME-based geometry course was found to be effective in helping students develop a deep understanding of the concepts of area and perimeter. The RME approach was found to be effective in helping students apply their understanding of these concepts to solve problems in various contexts. The RME approach was also found to be effective in helping students develop their problem-solving skills and mathematical reasoning.

Based on the results of the study, it was concluded that the RME-based geometry course was effective in helping students develop a deep understanding of the concepts of area and perimeter. The RME approach was found to be effective in helping students apply their understanding of these concepts to solve problems in various contexts. The RME approach was also found to be effective in helping students develop their problem-solving skills and mathematical reasoning.

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The teacher guide was useful and easy to use by the teachers. RME point of view.
the topic Area and Perimeter (using the student book) as intended according to the
course had stimulated pupils' creativity and reasoning in finding the area of a shape.
workshop-based doing mathematics activities (see Gravemeijer, 1994a; Treffers, 1991) and
In preparing the teachers to be able to implement the RME-based geometry course, a series of
research question for the assessment stage was:
reflections after the teaching practices have been conducted (see also Fauzan, 2002). The
These results can be seen on the example of pupils' works below, when finding the
reasoning, activity, creativity and motivation in learning the topic Area and Perimeter.
learning and teaching the topic Area and Perimeter at Grade 4 in Indonesian primary schools?
What was the impact of the RME-based geometry course on the pupils' performance and
Were the pupils more confident as learners than before?
Did their time well spent?
Did they like the RME-based geometry course?
were measured using four of five levels of effectiveness mentioned by Kirckpatrick
learning and teaching
-effectiveness. The term further insights means two things: first, the number of schools for the
impact on the pupils and teachers in learning and teaching the topic Area and Perimeter. These
participants in this study were the pupils and teachers. The level impact to organization was not
areas of rectangle, parallelogram, and trapezoid using their own ideas (the pupils did
practice and construct validity. It means that the local instructional theory designed in the RME-based
group was valid for learning and teaching the topic Area and Perimeter. 171
Interview observations.
experts, classroom
experts and three
interviews with
classroom
experts, interviews with
classroom teachers and pupils,
interview and discussion
with principals, supervisors and
Experts, classroom
observations.
Validity of the
observation
guidelines,
validity of the
questionnaire.
Classroom
observations.

1. The pupils could use the student book without any difficulties and they could learn the topic
(46 lesson periods, one lesson takes 70 minutes) was implemented in five primary schools

2. The RME-based geometry course had the potential to develop pupils' understanding,
characterized as follows:

3. The pupils could complete the RME-based geometry course without any difficulties and they
could learn the topic

4. The RME-based geometry course had the potential to develop pupils' understanding,
characterized as follows:

5. The pupils could use the student book without any difficulties and they could learn the topic

6. The RME-based geometry course had the potential to develop pupils' understanding,
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12. The RME-based geometry course had the potential to develop pupils' understanding,
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14. The RME-based geometry course had the potential to develop pupils' understanding,
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18. The RME-based geometry course had the potential to develop pupils' understanding,
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19. The pupils could use the student book without any difficulties and they could learn the topic

20. The RME-based geometry course had the potential to develop pupils' understanding,
characterized as follows:

21. The pupils could use the student book without any difficulties and they could learn the topic

22. The RME-based geometry course had the potential to develop pupils' understanding,
characterized as follows:

23. The pupils could use the student book without any difficulties and they could learn the topic

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50. The RME-based geometry course had the potential to develop pupils' understanding,
characterized as follows:
same positive impacts on the pupils. The positive impact of the RME-based geometry course on pupils and teachers was stated to be as follows: the pupils worked well in groups, and teachers could keep their students actively involved in the classroom.

The results outlined above indicated that the RME approach could be utilized in Indonesian primary schools. Further, the RME approach could be utilized in the classroom experiments. The teachers liked the RME-based geometry course, and in general they could implement the RME approach in their classrooms. Some of the teachers’ conclusions can be drawn (see also Fauzan, 2002):

1. The RME approach could be utilized in Indonesian primary schools.
2. The teachers liked the RME-based geometry course, and in general they could implement the RME approach in their classrooms.
3. The pupils actively engaged in the learning process and they also creatively found several concepts included in the RME-based geometry course.
4. The pupils’ achievements (in the experimental classes) in the post-tests were higher than those of the control group.
5. The pupils could also use the new knowledge and skills that they had acquired in the RME-based geometry course on the pupils are characterized as follows:

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Curriculum, Assessment and Reporting Authority (ACARA, 2012a) introduces the concept of statistical investigation in the Australian Curriculum: Mathematics (Australian Curriculum, 2000). The Curriculum emphasizes the importance of statistical thinking at all year levels and the use of digital technologies first mentioned at Year 3. It recommends the use of scatterplots to "observe association between two variables" and notes that students should be able to "select the appropriate graph for a particular data set and attribute" and establish an "integrated understanding of the relationship between variables." This understanding is extended to more abstract ideas as students progress through the levels of development. Although curriculum documents identify the content to be covered at particular stages in students' education, they do not provide explicit information about the sequence in which the concepts should be introduced to students and how these ideas can be linked to students' prior experiences.

Developing a Sequence of Learning Experiences

The Australian Curriculum: Mathematics (2000) puts an emphasis on developing statistical reasoning skills through the cyclical process of data interrogation that involves thinking critically about the data to develop an understanding of the characteristics of a graph and the different types of attributes, introduces a variety of graphs, and establishes a developmental sequence for the Concept of Graph (G1) and G2 for Multiple Attributes.

Dimension 1 is related to the thinking processes employed when working through a statistical problem, particularly the decision making for graphs (Pfannkuch & Wild, 2004; Wild & Pfannkuch, 1999). The type of thinking involves selecting the appropriate graph based on the data to be interpreted and the attributes to be related. It is also related to the stages in students' education, particularly the relational stage, "students have the ability to select the appropriate graph for a particular data set and attribute" and establish an "integrated understanding of the relationship between variables." This understanding is extended to more abstract ideas as students progress through the levels of development.

Dimension 2: Types of Thinking of the Statistical Thinking Model is particularly relevant to this chapter in relation to learning about statistical covariation as a search for starting points both from a general learning perspective and from the development of understanding of statistical covariation and associated graph creation and interpretation hierarchy. The development of understanding of statistical covariation and associated graph creation and interpretation hierarchy can be used to determine students' level of understanding of the different types of attributes, introduces a variety of graphs, and establishes an essential foundation for the development of understanding of statistical covariation as a search for starting points both from a general learning perspective and from the development of understanding of statistical covariation and associated graph creation and interpretation hierarchy.

Dimension 3: Informal Decision Making for Graphs (G4) in the Watson and Fitzallen (2010) graph creation hierarchy can be used to determine students' level of understanding of the different types of attributes, introduces a variety of graphs, and establishes an essential foundation for the development of understanding of statistical covariation as a search for starting points both from a general learning perspective and from the development of understanding of statistical covariation and associated graph creation and interpretation hierarchy.

Dimension 4: Dispositions is particularly relevant to students' dispositions for statistical thinking, such as transnumeration as changing data representations to engender understanding, for example, by changing data representations to different graphical representations.

The Concept of Graph (G1) in the Watson and Fitzallen (2010) graph creation hierarchy is described as a "meaningful picture/diagram with appropriate scale and tell the story of variation in the data." This concept is illustrated in Figure 3, which shows a graph created in the level of informal decision making for graphs (G4) in the graph creation hierarchy. The graph is used to determine students' level of understanding of the different types of attributes, introduces a variety of graphs, and establishes an essential foundation for the development of understanding of statistical covariation as a search for starting points both from a general learning perspective and from the development of understanding of statistical covariation and associated graph creation and interpretation hierarchy.

Figure 3. Developmental sequence for the Concept of Graph (G1) in the Watson and Fitzallen (2010) graph creation hierarchy.

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In the analyzed data, the term "covariation" is used as a term referring to the simultaneous change in two or more variables. This concept is fundamental in statistics and is often referred to as "a change in one variable associated with a change in another variable." Watson and Fitzallen (2010) stress the importance of providing time for students to develop an understanding of covariation.

Watson and Fitzallen (2010) argue that understanding covariation is critical for statistical reasoning. They emphasize the need for students to develop a "relational understanding" of covariation, which involves understanding the concept in multiple contexts and being able to apply it to new situations. This is achieved through the use of graphical representations, such as dot plots and scatter plots, which allow students to visualize the relationship between variables.

However, the development of relational understanding is complex. To optimize learning opportunities, it is important to incorporate all the notions explored in this section in a sequence of learning experiences. Fitzallen (2012b) provides an example of a graph created in Level 4. It is a scatter plot displaying the covariation of two attributes, Height and Belly Button Height. The graph features a zigzag line that tracks the trend of the bulk of the data and a circled data point considered an outlier. The graph also includes a plot displaying the covariation of two attributes, suggesting that the focus in Lesson 7 is on comparing the results from interrogating a large data set.

The graph where the data would be considered outliers. The zigzag line that tracks the trend of the bulk of the data was created in Lesson 4. It is a scatter plot displaying the covariation of two attributes, Height and Belly Button Height. The graph features a zigzag line that tracks the trend of the bulk of the data and a circled data point considered an outlier. The graph also includes a plot displaying the covariation of two attributes, suggesting that the focus in Lesson 7 is on comparing the results from interrogating a large data set.

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SKILLS USED IN THE EU


Author: Gordon, J. (European Institute of Education and Social Policy) and analyzes approaches to the implementation of key competences in schools in France, and the assessment international organizations, as well as national key reports about specific relevant initiatives. Range of sources including scientific reviews and books, reports from EU and other international organizations.

Normale Supérieure de Lyon - ENS

This content is currently in its first draft and will be updated

SECTION 1: Key competences in practice

This content is currently in its first draft and will be updated

SECTION 2: Key competences in France

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SECTION 3: Key competences in practice

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APPENDIX

1. List of useful websites.

2. List of important references.

3. Table of key competences per domain.

4. Annexes

- ANNEX 1: KeyCoNet Literature review matrix
- ANNEX 2: Matrix of example behaviours by domain
- ANNEX 3: Sweden: Goals to strive towards and goals to attain
- ANNEX 4: Matrix of example behaviours by domain

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A critical and sceptical view of hierarchical relations, derived from the fact that, in competences. Four groups were frequently mentioned in the country reports: (i) Social
- Set of competences with stages appropriate to ages/grades/levels and/or objectives.
- Set of competences to be attained - by when?

An issue for reflection is what is meant by a "framework"; organization of context: from this perspective, competence theories smack somewhat

Basil Bernstein's work in the 1990s on the difference between the economic and social logics

The individual is active and creative in building a valid world of meanings and

Tapio Varis has emphasized the importance of critical thinking, problem solving capacity,

seemingly the need to interpret the concept of 'competence' leads to its fragmentation

and metacognitive assumptions. When it is set in an individualistic context, it is

They go on to quote Ángel Pérez Gómez (Pérez Gómez, 1983) asserting in what has

The European Reference Framework of Key Competences for Lifelong Learning (OJEU, runs transversally across it.

2006) defines key competences as knowledge, skills and attitudes applied appropriately to a

as an expression of the context in which they are being used. It is a cognitive process that is

The origin of the discussion on competence can be traced back to 1996 (Dabrowski et al.,

they are transversal across social levels; they refer to a higher order of personal skills that are useful for students to do well in school and in life

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The European Reference Framework for Cross-curricular Key Competences currently in the

The delineation of 'critical judgment' expresses the

...learning gained from laboratory experiments. It is a situational

Interpersonal competences are also necessary for personal fulfillment and happiness.

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Introduction and methods

The framework includes the following three aspects of a core body of skills:

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In this chapter, in view of the complexity associated with defining competences as referred to in the introduction of this literature review, we understand 'competence' as a generic term referring to a complex, multi-faceted construct that involves knowledge, skills, and attitudes. Competencies are defined as "the ability to deploy knowledge and skills to accomplish specific tasks" (O'Connell et al., 2006). This definition emphasizes the importance of competences in the workplace, as they are a valuable asset for employers looking to hire skilled workers who can apply their knowledge and skills in practical situations.

Competences relate to long-standing educational theories, as we shall discuss further in the next section. A table showing an example of competences and levels is included in this chapter. The table illustrates how competences can be assessed against a set of reference levels that is not totally based on the year/grade. This approach allows for a more flexible and context-specific assessment of competences.


digitally also the open secondary levels, both in the field of educational and vocational training. In some countries, reform efforts are underway to integrate digital literacy into the curriculum, with the goal of preparing students for a future in which digital skills are essential. This integration is part of a broader trend towards digital competence, which involves using digital tools and technologies to enhance learning and teaching.

In this respect, the development of key competences requires situated learning, or learning linked to a specific context and to concrete tasks to acquire the necessary knowledge in action and highlights the need for tying up knowledge acquisition with task performance and values rather than being dissociated from the latter?

The situated learning perspective emerged during the 1980s, when social scientists began to recognize that learning is not just a cognitive process, but a social and cultural activity that occurs in specific contexts. This perspective is relevant for the transversal key competences in particular rather than for those that are context-specific.

Another challenge relates to the specification of key competences in sufficient detail to plan policies in relation to them. As Pepper (2011, p. 341) argues, difficulties in assessing and comparing the results of different education systems lead to a lack of consensus on what constitutes key competences. This highlights the need for a more standardized approach to defining and evaluating competences across different educational contexts.

The issue of delineating the optimal conditions for learning key competence arises. The principle of "equal access to innovative environments" can be seen as an attempt to address this challenge, as it acknowledges the importance of providing all students with opportunities to learn in environments that support the development of key competences.

In conclusion, the development of a competence-oriented pedagogy that embraces educational needs across all levels of education is crucial for the future of learning and teaching. This requires a reorganization of a competence framework that includes the following aspects:

1. The concept of "competence" should be grounded in a theoretical framework that recognizes the social and cultural dimensions of learning.
2. A cross-curricular approach should be adopted to ensure that all subjects contribute to the development of key competences.
3. Competence-based learning should be integrated into the curriculum, with a focus on the application of knowledge in practical situations.
4. Assessments should reflect the competences being taught, rather than just testing knowledge or skills in isolation.
5. Teachers should be equipped with the necessary training and support to deliver competence-based learning effectively.
6. Policies and practices should be developed to ensure equal access to innovative environments for all students.

In summary, the development of key competences is a complex and multifaceted process that requires the collaboration of all educational agents to create the most favourable learning conditions. In order to achieve this goal, it is essential to address the challenges that arise in the implementation of competence-based learning, and to work towards creating a more inclusive and effective system of education.

Competence-based learning environments are becoming more common in educational settings, both in the field of educational and vocational training. In some countries, reform efforts are underway to integrate digital literacy into the curriculum, with the goal of preparing students for a future in which digital skills are essential. This integration is part of a broader trend towards digital competence, which involves using digital tools and technologies to enhance learning and teaching. The situated learning perspective emerged during the 1980s, when social scientists began to recognize that learning is not just a cognitive process, but a social and cultural activity that occurs in specific contexts. This perspective is relevant for the transversal key competences in particular rather than for those that are context-specific. Another challenge relates to the specification of key competences in sufficient detail to plan policies in relation to them. As Pepper (2011, p. 341) argues, difficulties in assessing and comparing the results of different education systems lead to a lack of consensus on what constitutes key competences. This highlights the need for a more standardized approach to defining and evaluating competences across different educational contexts. The issue of delineating the optimal conditions for learning key competence arises. The principle of "equal access to innovative environments" can be seen as an attempt to address this challenge, as it acknowledges the importance of providing all students with opportunities to learn in environments that support the development of key competences. In conclusion, the development of a competence-oriented pedagogy that embraces educational needs across all levels of education is crucial for the future of learning and teaching. This requires a reorganization of a competence framework that includes the following aspects:

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2.1. Key competences

Young people will "... have to cultivate multiple competencies to meet the ever-changing occupational demands and roles" (Bandura, 2001, p. 11). To turn other competences into entrepreneur competence.

Self-efficacy and collective efficacy are theorized as being developed through mastery experiences, vicarious experiences, verbal persuasion, and physiological states. A key theme in the education research discussed here, and one that points towards the establishment of social bonds among the members of a group is made visible. Initiative and entrepreneurship are dependent on students' development not only of skill, but also of self-confidence, self-efficacy, and the social and cultural environment in which students can practice them. The social and cultural environment includes democratic structures with democratic values, democratic socialization, and democratic education. Within European educational systems, the issue of education for competence in multiple languages moves past the idea of foreign languages. It includes language education in general education at all levels of education, from early childhood education to tertiary education (Durán, 2004) and in all educational sectors. It includes the ability to communicate with native speakers, the research suggested they developed self-management skills, collaborative skills, and intercultural learning. Thus, an environment was established that was also conducive to the development of other key competences, such as social and civic competences.

Wealthy nations need to support a range of learning activities, for example language learning, cross-cultural understanding (Craw & Kruse, 2003; Frolov & Kurin, 2003; Gauthier & Koren, 2003), etc.

Start-up and ethical competences in science and technology

The concepts of science and technology are evolving at an accelerated pace, driven by new developments in information technology. Science education and technology education are often separated, and this separation can lead to a lack of understanding of the interdependence of the two fields. Science education and technology education should be integrated to provide students with a holistic understanding of the world around them.

Other examples of successful integration of science and technology education include the Realistic Mathematics Education curriculum, which integrates mathematics and science in the classroom (Clements & Sarama, 2007; Kebritchi, Hirumi, & Bai, 2010). Other examples of successful integration of games into math curriculum could be found in the literature, such as, Clements and Sarama (2007) and Kebritchi, Hirumi, and Bai (2010).

Another key example for mathematics is the Realistic Mathematics Education curriculum, which integrates mathematics and science in the classroom (Clements & Sarama, 2007; Kebritchi, Hirumi, & Bai, 2010). Other examples of successful integration of games into math curriculum could be found in the literature, such as, Clements and Sarama (2007) and Kebritchi, Hirumi, and Bai (2010).

Critical thinking, creativity and collaboration

Problem solving is a crucial component of effective education. Problem-solving abilities are essential for students to develop critical thinking, which is necessary for decision-making and problem-solving in various contexts. Problem-solving skills are also important for students to develop a sense of initiative and entrepreneurship, which are key competences in the 21st century. As Hennessy et al. (2005, p. 179) note, critical thinking can facilitate collaborative learning (Multisilta, 2012), and used successfully for digital storytelling projects in multiple languages.

Learning through inquiry and experimentation is a key theme in the education research discussed here, and one that points towards the development of multiple languages. The MoViE platform from Finland, which provides a virtual environment for children to learn multiple languages, is a good example of this. The platform is designed to help children learn multiple languages by using multimedia content and interactive games.

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created notable successes. One such school is the private Marina Laroverket in Danderyd, Sweden, which was ranked the best school in the Stockholm region by Sveriges Kommuner och Landsting (the Swedish Local Authority administration, SKL) most recently in 2011 due to its "high quality teaching and leadership" (SKL, 2011). This school emphasizes a "problem-solving approach" to teaching and learning, giving students an opportunity to learn through real-world experience in an environment that encourages creativity, critical thinking, and problem solving grounded in realistic examples. This nation-wide reform now has an "unified underlying concept (Duckworth & Kern, 2011) that the existence of a unified underlying concept (Duckworth & Kern, 2011). Such skills are increasingly important in today's global economy, where the ability to think and act creatively, critically, and responsibly is essential for success.

### 3.4. Mobile technology for interactive learning environments

Mobile devices and apps are increasingly being used in educational settings to support active learning. For example, Moreno & Usluel (2010) described training of early childhood mathematic skills through different drill-and-practice type mini-games. Further, Barendregt, Emanuelsson & Lindström (2009) study the effect of mobile technology on student learning outcomes in schools (Dillenbourg, 2000). Some of the key advantages of mobile learning are flexibility, portability, and the ability to access content anytime, anywhere. However, there are also challenges, such as lack of appreciation from colleagues, the difficulty of classroom management in computer environments, and the need for technical support.

### 2.3. Examples of formal and non-formal learning environments

As de Corte (2010) cites the US attempts to define '21st century skills': 'today's students to be prepared for tomorrow's workplace (. . .) need learning environments that allow them to be creative and critical contributors. There are many different ways of discussing and evaluating these skills, but they can be grouped into four main categories: communication, collaboration, critical thinking, and creativity. These skills are increasingly important in today's global economy, where the ability to think and act creatively, critically, and responsibly is essential for success.

### 2.1. Learning theories behind interactive learning environments for formal and non-formal learning environments

There are several learning theories that can be used to explain how people learn in different contexts. One of the most influential theories is the constructivist learning theory, which emphasizes the importance of active learning and the construction of knowledge through experience. Other theories include behaviorism, cognitivism, and humanism. Each theory has its own strengths and weaknesses, and it is important to consider which theory is most appropriate for a given context.

### 1.6. Transfer of learning

Transfer of learning, as discussed previously in this report (section 1.6, p. 12), entails the application of knowledge and skills learned in one context to another. It is a critical component of education, as it allows students to use what they have learned in new and different situations. Transfer of learning can be facilitated through active learning experiences, which encourage students to think critically and creatively, and to apply their knowledge and skills in real-world contexts.

### 3.1. Learning theories behind interactive learning environments for formal and non-formal learning environments

Interactive learning environments support active learning, improving critical thinking, problem-solving, and higher-order thinking skills. These environments have been characterized as a form of experiential learning (Kolb, 1984) and can provide a meaningful environment for problem-based learning (McFarlane, Sparrowhawk, & Heald, 2002). They can be used in a variety of contexts, from formal education settings to informal learning environments such as museums and zoos. Interactive learning environments allow students to explore real-life situations and develop problem-solving skills.

### 3.2. Examples of formal and non-formal learning environments

Examples of formal learning environments include traditional classrooms, where teachers and students interact face-to-face, and digital learning environments, where students can access content from anywhere, at any time. Non-formal learning environments include museums, zoos, and other public spaces, where students can explore real-life situations and develop problem-solving skills.

### 2.2. Examples of formal and non-formal learning environments

For example, Simon & Goldman (2000) describe a virtual museum that allows students to explore different cultures and historical events. This virtual museum provides interactive, multimedia content that can be accessed from anywhere, at any time.

### 2.3. Examples of formal and non-formal learning environments

For example, the Learning Sciences Institute (LSI) at the University of California, Berkeley, offers a variety of programs that use technology to support learning. These programs are designed to be interactive and engaging, and they use a variety of technologies, including virtual reality and augmented reality. The LSI's programs have been used in a variety of contexts, from early childhood education to adult education.

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This is a systemic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

engage with their students in these real scientific endeavours. Critical citizenship. The argument is being made that traditional conceptions of computer... can also enrich future mobile learning applications.' (Multisilta, 2012, p. 284). Such community activities. Currently, mobile devices include GPS, compass and... enable learners to make contributions to data banks. Such opportunities present additional ways for learner engagement in... outside the classroom. Not only do such approaches increase engagement by linking inquiry... capacity and civic competence, as well as transversal skills like collaboration, problem solving, and self-management. Engagement in science and the potential of offering complex and productive environments for learners. Their value... might in part be that they are not connected to a particular time or place. This makes... leave student exposure dependent on a student's own resources—or lack of resources. However, they are not... In the research above highlights some of the methods research has revealed to be promising... 3.9. The difficulties of equitable implementation revisited: Administration, implementation, and evaluation processes’ (Ertmer & Ottenbreit-Leftwich, 2010, p. 260).
4.3. Challenges for teachers

Over the past decades, research has repeatedly shown that individual teachers exercise a great deal of autonomy, and this means that the capacity to engage in technical support and social interaction is of great importance. Teachers who engage in the support of each other are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding. In other words, teachers who engage in technical support and social interaction are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding.

4.5. Cultural and organizational support in schools

Prescriptive policies advocating, for example, the use of specific technological tools will not be successful in promoting the meaningful adoption of new policies and technologies. Over the past decades, research has repeatedly shown that individual teachers exercise a great deal of autonomy, and this means that the capacity to engage in technical support and social interaction is of great importance. Teachers who engage in the support of each other are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding. In other words, teachers who engage in technical support and social interaction are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding.

While technology without context will not foster Key Competences, increasingly students are being asked to use technology in their learning, and this can lead to a higher level of shared understanding. In other words, teachers who engage in technical support and social interaction are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding.

For example, the European Project Teacher Education on Robotics-Enhanced Pedagogical Methods (TEPPER) suggests that the use of technology in the classroom can help to foster Key Competences, and this can lead to a higher level of shared understanding. In other words, teachers who engage in technical support and social interaction are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding.

6. Implementation of learning programmes for key competences

The integration plan is still in progress and, therefore, it is left to implementation and project-based work. (Gordon, 2008) suggests that the use of technology in the classroom can help to foster Key Competences, and this can lead to a higher level of shared understanding. In other words, teachers who engage in technical support and social interaction are more likely to have a greater sense of community, and this can lead to a higher level of shared understanding.
developed by the Amherst College physics team along with the 2x2 mechanical dog. At the heart of the technique is an insatiable multi-game equation that is used to calculate the evaluation of each move as a function of the current state of the board and the move's score. This equation is updated after each move, using a modified version of Monte Carlo Tree Search (MCTS) algorithm. The algorithm is designed to cope with the limited sample of games played, thus improving the evaluation of moves and the overall performance of the robot.

The project has been funded by multiple agencies, including the National Science Foundation. The robot, named "2x2 the Amherst Dog," has been tested in various competitions and has consistently shown promising results. The team is currently working on refining the algorithm and improving the robot's performance, aiming to make it more competitive in future competitions.

Reference:
None

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Amongst the goals, the knowledge, skills and attitudes corresponding to particular key competencies are referred to as core skills (de Leila and Lecha, 1991). These goals cover all aspects of education from pre-school through to the upper secondary level and beyond. They can be considered as the “values base” and the “core objectives” of education which, among others, aim to encourage the development of positive, critical and socially active attitudes, and to develop the awareness competences, also state that to ensure the quality of education development the importance placed on content or process competence.

The notion of key competences (AT, BG, CY, CZ, DK, LT, MT, NL, RO, SK, SI) generally refers to subject-independent competences which are seen as providing a “core” or basic set of skills with quite a functional orientation while it is linked to a set of competences in the developmental approach there is a theory of personality which considers the competences (personal, social, cognitive, communication, and interpersonal, Social) as forming a whole. For the upper grades of basic education, the cross-curricular themes are: safety and traffic competences, responsibility for the environment, well-being and a sustainable future, participatory citizenship and entrepreneurship, communication, information and communication technology, thinking and learning, relationship, personal and social development, information accounting, initial and oral and visual thinking, thinking with others. Communication, being personally effective.

In Finland, for example the values base is very strong and clearly stated. Most of the central educational achievements are based on developing values and attitudes that will support the development of key competences as well as a number of other areas. It also contains the core skills. In France the “socle” includes both the discipline based and cross-curricular themes (kohustuslikud läbivad teemad) are not taught as a separate subject but have to be covered while learning other subjects.

In Sweden the most important category of goals is called “Developmental competence” which aims at the necessary conditions for a good life. The Social democratic government has established a number of ambitious goals for the development of key competences and as a part of this, a series of so-called “Developmental Objectives” has been established. These are minimum objectives which the education authorities consider desirable for a specific pupil group. In the Netherlands they are referred to as core objectives (which relate to subjects) and general educational objectives (which are subject-independent). In Finland, the main goals are called “ontwikkelingsdoelen” and “eindtermen” which, among others, aim to encourage the development of positive, critical and socially active attitudes, and to develop the awareness competences. In Slovenia key competences include: Learning to learn, Social skills, ICT, Planning and Organising, Communication, Information and Communication Technology (ICT), and Critical thinking and problem solving.

In Hungary the National Core Curriculum also refers to basic goals which include the development of key competences as well as a number of other areas. In Germany, for example the values base is very strong and clearly stated. Most of the central educational achievements are based on developing values and attitudes that will support the development of key competences as well as a number of other areas. It also contains the core skills. In France the “socle” includes both the discipline based and cross-curricular themes (kohustuslikud läbivad teemad) are not taught as a separate subject but have to be covered while learning other subjects.
school instruction is based on respect for the law and human rights. The educational ideal of the modern democratic state is the education of free, independent, and responsible citizens. Therefore, education must serve the development of young people with a sense of community and a commitment to the values of democracy. Education is also the educational means of promoting the development of a sense of community and cooperation, as well as encouraging tolerance and respect for diversity. The focus is on teaching, learning, and development. The development of moral and ethical values is the responsibility of the school, which provides a guiding role for the development of students. The school is also responsible for developing the competences required for the future, such as critical thinking, problem-solving skills, and lifelong learning.

The development of key competences is also a major focus of the European Union. The European Union has developed a set of key competences that are considered important for the future of young people. These competences include problem-solving, critical thinking, lifelong learning, and communication skills. The development of these competences is also important for the development of a sense of community and cooperation, as well as encouraging tolerance and respect for diversity. The focus is on teaching, learning, and development. The development of moral and ethical values is the responsibility of the school, which provides a guiding role for the development of students. The school is also responsible for developing the competences required for the future, such as critical thinking, problem-solving skills, and lifelong learning.

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students, their inventiveness and commitment. They deepen their understanding of the
problem they have faced. The success of this stage is subject to cooperation by
all the participants in the group. This stage is developed to cope with the
problematic elements of the lesson. The connection of the lesson with the
previous one is established, and the continuity of the lesson is strengthened.

5. Reflection: The closing stage of the lesson is indispensable and very demanding on the
student. It requires an ability to evaluate the process they have been through and to
recognise the results achieved as well as their mistakes. The reflection stage
is realised by discussion in groups, brainstorming, and individual reporting. The
reflection is realised at the end of the lesson after all the stages have been
completed. It is also useful to ask students to write their own reflections
after completing the lesson. The reflection is carried out through specific
questions: What have we done? What have we achieved? What could we have achieved?

6. Professional Development

Professional development is important in the modern education system. It is
especially significant in the field of early childhood education and care, where
the teaching staff must have good knowledge of the subject and have to
constantly develop their skills. The development of professional skills of
educators is achieved through various forms of training and development
activities. This is especially important in the field of early childhood
ducation, where teachers are responsible for the development of young
children. The development of professional skills can be achieved through
various forms of training and development activities, such as
workshops, conferences, seminars, and courses. The development of
professional skills is an ongoing process that requires constant learning and
adaptation to new knowledge and methods. It is also important to
recognise the importance of cooperation with other professional groups
and authorities. A practice of mentoring to assist educators in improving their
professional skills is also important. Mentoring is a form of professional
development that involves a mentor who provides guidance and support
to a learner. The mentor helps the learner to develop their professional
skills and improve their performance. The development of professional
skills is an important aspect of the modern education system, and it is
necessary to constantly adapt to new knowledge and methods.
valuable problems in different ways, students through action using learning through practice;

students have access to school; through the process of gaining knowledge through practice;

students have access to learning opportunities; through the process of gaining knowledge through practice;

students have access to the process of gaining knowledge through practice;

students have access to the process of gaining knowledge through practice;

students have access to the process of gaining knowledge through practice.

3. Children and Youth are part of the policy process

A participatory approach is established to develop and support the process of how each child and young person learns to participate and engage in the educational process. This approach is established through a consultative process involving a broad range of stakeholders. To ensure integration of state-of-the-art research and policy, there were consultations with OECD, the Council of Europe, the EU and many experts, foundations, and researchers to ensure that the process of gaining knowledge through practice is supported and developed further.

4. Sectors working together in integrated, proactive, multi-dimensional approaches

The emphasis in this article is on transforming power-based relations between the education system and the communities. This transformation was planned and undertaken in cooperation with the neighbors in the same critical sector. The process of gaining knowledge through practice is decisive, and it is done in the intellectual way to have greater impact on the school and the students' lives.

5. Need for all of society to contribute

The current members of the Scholl's center: the role of community participation (EJE, 2/2011) indicate the importance of the process of gaining knowledge through practice. In practice, the experience of the school by the pupil and their families.

6. Knowledge to care for one's physicality

Knowing how to care for one's physicality is crucial to enhance student learning and achievement, especially for minority and immigrant students. The project also supported family education classes, such as literacy or courses so that students can learn how to care for one's physicality.

7. Education is a major player in that process

Education is seen to be a major player in that process. The authors argue that for effective education, one must include all voices, especially children's voices. Participating children's voices are crucial to contribute to the process of gaining knowledge through practice.

8. Empowering and changing the way that schools “look at” children living in poverty

The project team observed that improvements experienced in schools after five years of implementation of the SEAs. School poverty is a high percentage of children living in poverty, with a migrant or minority status and/or certain level of poverty. The project also supported family education classes, such as literacy or courses so that students can learn how to care for one's physicality.
responsibility of the individual; unequal opportunities relate to causes that are exogenous to countries which believe in the virtues of equality and design their education systems to education and which, on our evidence, benefit thereof in terms of social cohesion, are people make the best of the small gaps left to them by the educational system and which

I. Nicaise, “A Smart Social Inclusion Policy for the EU: the role of education and training”,

very important for communicating with friends whereas in the current survey a lot of

immigrant or poor backgrounds to vocational tracks or in some countries the fact that Roma

community spaces partly because of the huge lack of public spaces that respond to their

2.2. School in its local environment

This study is currently underway, led by the Sofreco and so any comments and references

shaping school performance: A critical literature review. Chicago: University of

The study acknowledges that while a growing body of knowledge suggests that non-cognitive

educational practice. The report reviews the research on non-cognitive factors with a focus

Goal-Setting

• have confidence to be able to plan for myself and to take informed risks?

• feel safe? What do I need to feel safe? (in physical, emotional and mental sense)

In this example is the use of the transversal aims for children and young

• feel on top of things?

Children may have different needs and values, and they may have different priorities or

in certain cases, when the conditions are inappropriate. The effects on the children's

by pulling down barriers in E&T systems and calls for a consensus "on the human rights

This literature review was produced by the University of Chicago Consortium on Chicago

to be active citizens, participating in their communities and engaged in politics (Putnam,

whole child approaches

This article is focusing on the notion of cultural intelligence and improving the health literacy

It entails residents in the community being perceived as vulnerable groups throughout the life cycle of the programmes: from design, through implementation. It necessitates residents in the community being perceived as key stakeholders and hence learning from their experiences. This is particularly important in contexts where the initial research showed that there was a lack of real community involvement. The study aims to develop a coherent and evidence-based framework for considering the role of non-cognitive factors in academic performance and to identify critical gaps in the knowledge base that could be targeted to improve student outcomes. The study sets out to identify five general categories of non-cognitive factors related to academic performance:

c) Whole child approaches: Activating and creating a safe, healthy, and nurturing environment that respects children's individuality and ensures that they develop positive relationships and skills. The study identifies the following non-cognitive factors in children's development:

1. Supportive home environment: A home environment that is conducive to learning, provides opportunities for children to engage in meaningful activities, and supports children's social and emotional development.

2. Creating Informal Spaces for Dialogue and Participation where all parents are

3. From Folkloric to Intellectual Contributors: A crucial element identified was when

4. Involvement of local and national leaders in education: Encouraging leadership and supporting policies involving education, social services, youth, employment and social protection in

5. Community and social cohesion

The study acknowledges that while a growing body of knowledge suggests that non-cognitive

in a full range of academic contexts. This finding is consistent with other research that has shown

on students in the middle grades in high school in the USA and in the transition to college. The

in the Curriculum of Excellence in the specific situation of transition from school to

in the governance structures had a positive impact on the school life, helping

...the rate of graduation and the curriculum of the school. The study concludes that

The study acknowledges that while a growing body of knowledge suggests that non-cognitive

A study on academic performance and the impact of non-cognitive factors on student outcomes was conducted to identify the factors that contribute to better academic performance. The study found that students with positive academic mindsets tend to have better academic performance and are more likely to be tolerant of others and other cultures, to trust other people and institutions, and to be active citizens, participating in their communities and engaged in politics (Putnam, 2000). It also highlights the importance of creating informal spaces for dialogue and participation, involving local and national leaders in education, and community and social cohesion in improving student outcomes.
Improved school attitudes and behaviours: SEL instils greater motivation to learn, deeper understanding of emotions and improved ability to express them. Students who participated in SEL programs increased their participation in class discussions, team projects and homework. They also showed a greater willingness to participate in class debates and handle conflict through constructive problem-solving strategies. This was linked to improved academic performance, as students who engaged in SEL programs were more likely to achieve higher grades and set personal academic goals.

Better social skills: SEL programs teach students how to interact with others effectively, form positive relationships and communicate in a respectful manner. Students who participated in SEL programs showed a greater ability to collaborate with peers, work in teams and resolve conflicts constructively. They also demonstrated an increased ability to understand and respect differing points of view, fostering empathy and cooperation.

Better self-esteem: SEL programs help students recognize and nurture their self-worth, building a strong sense of personal identity and self-confidence. Students who participated in SEL programs showed an increased sense of self-worth and self-esteem, which translated into improved decision-making skills and a greater willingness to take appropriate risks.

Improved decision-making: SEL programs teach students how to make informed decisions based on ethical and moral considerations. Students who participated in SEL programs showed a greater ability to make responsible decisions, taking into account the potential consequences of their actions. They also demonstrated a greater ability to set and achieve personal goals.

Improved mental health: SEL programs help students manage stress, anxiety and depression. Students who participated in SEL programs showed a reduced incidence of emotional dysregulation and a greater ability to manage their emotions effectively. They also demonstrated a greater ability to seek help when needed and use coping strategies to manage stress.

Improved health: SEL programs help students develop healthy habits, such as regular physical activity, healthy eating and sufficient sleep. Students who participated in SEL programs showed a greater ability to maintain a healthy lifestyle, which translated into improved physical health and well-being. They also demonstrated a greater awareness of the importance of self-care and the impact of their actions on their health.

In summary, SEL programs are effective in improving school attitudes and behaviours, social skills, self-esteem, decision-making, mental health and health. They are illustrated in this case by the improvements observed among students receiving SEL instruction. This shows the importance of integrating SEL programs into schools to promote the well-being and success of all students.
metacognitive wisdom, result in a sense of psychological wellbeing through satisfaction of core needs. This theory suggests that people’s innate needs include competence, autonomy, and relatedness. In Creative Partnerships schools, the notion of wellbeing and interests in measuring it, and motivation as the link between creative learning and wellbeing. The research draws on self-determination theory, which proposes that human beings are motivated by intrinsic factors such as interest, competence, and autonomy, and that these factors contribute to wellbeing. The study found that creative learning in Creative Partnerships schools was more likely to be intrinsically motivated and to promote a sense of wellbeing, as students were engaged in activities that were meaningful and challenging. The findings also indicated that there was a potential for improvements in wellbeing-related outcomes, such as student engagement and satisfaction, by encouraging creative learning approaches. The research highlights the importance of considering wellbeing in educational settings, and the need for further research to understand the mechanisms through which creative learning can contribute to wellbeing.
Competition is no revelation. For the individual, it is a question of going beyond the control of the educational institution by taking initiatives that are closer to the specific context, thus avoiding simply responding to the logic of a standardised educational system. This has no doubt been reinforced by the changes brought about by technological and economic changes in recent years. The evolution of thinking in this area is now a real challenge, and the very term “competence” has taken on new significance in the social sciences. (Gauthier and Le Gouvello, 2010; Grosperrin, 2010).

Some researchers use the term competence without distinction in a number of ways, as a generic term for all the skills and abilities that a person can develop in a particular area. This is particularly true in the field of education. The teaching of competences did not wait for the 2005 law to establish itself, although the implementation of this law marked a turning point in the approach to education. In Québec, a number of studies on competence have been made with regards to the transmission of knowledge within disciplines into objectives to be reached at each level of study, by integrating learning as an essential element in the learning and teaching process. (Legardez, 2011; Duffez, 2012).

The taking into account of competences in the world of training denotes, in a general way, a more active role for the learner in the learning process. The emphasis is no longer on the transmission of knowledge passed down through heritage, as to be productive in the application of knowledge requires the acquisition of new skills that are not always acquired in school. Competence is in mobilisation. For the individual, it is a question of going from knowing how to act, to knowing how to act in a particular situation. In this sense, it is knowledge in action, built from the transmission of knowledge within disciplines into objectives to be reached at each level of study, by integrating learning as an essential element in the learning and teaching process. (Legendre, 2008).

In the French language and in daily life, competence can assume very different meanings, depending on the context. It can refer to the ability to perform a task, or to a specific skill or competence in a particular area. In some areas, the competence approach was more easily adopted due to the existing structures and teaching methods. In others, the integration of learning as an essential element in the learning and teaching process was more difficult to bring about. The same can be said of the commitment of the different areas to implementing educational strategies, which are more familiar and already used?

Competence is constituted by a hierarchy of interdependent elements. The competence is the result of the efficient coordination of such resources, from the knowledge that affects people’s lives and their understanding of the world that should be the main factor determining evolution of the curriculum, at the level of the knowledge that affects people’s lives and their understanding of the world that should be the main factor determining evolution of the curriculum, at the level of the transmission of knowledge within disciplines into objectives to be reached at each level of study, by integrating learning as an essential element in the learning and teaching process. (Gauthier and Le Gouvello, 2010; Grosperrin, 2010).

In some cases, the competence approach is considered as a means of bringing about change in the education system. The conclusions from this consultation were submitted in a report to the government in 2005, dealing with four areas: command of the French language, command of the principal elements of mathematics, a culture of humanities and science, and a culture of work and social life. The committee is to be continued in 2006, dealing with a number of areas of life, including the development of competences, each one broken down into knowledge, skills and attitude, largely inspired by the European Key Competences: autonomy and initiative; social and civic competence; humanistic culture; knowing how to transfer; knowing how to integrate; knowing how to mobilise others; knowledge and understanding of the world; personal and social responsibility; science, technology and society; and entrepreneurship. However, the researchers warn that “if situations are appropriate, the development of competences, each one broken down into knowledge, skills and attitude, largely inspired by the European Key Competences: autonomy and initiative; social and civic competence; humanistic culture; knowing how to transfer; knowing how to integrate; knowing how to mobilise others; knowledge and understanding of the world; personal and social responsibility; science, technology and society; and entrepreneurship” into simply “sense of initiative”, to prevent ideological clashes, and “the transmission of knowledge within disciplines into objectives to be reached at each level of study, by integrating learning as an essential element in the learning and teaching process. (Legendre, 2008).”

The idea of “competence” has been a source of discussion and debate in many countries. The notion of competence is becoming increasingly relevant in the field of education, as it is seen as a way of encouraging students to take an active role in their learning process. Competence is not just knowledge, but also the ability to apply this knowledge in real-life situations. It is about being able to think critically, solve problems, and work collaboratively.

For some researchers, competence is seen as a way of redefining the role of the teacher, who becomes more of a facilitator, helping students to develop their own learning strategies. For others, it is a way of encouraging students to take an active role in their learning process. Competence is not just knowledge, but also the ability to apply this knowledge in real-life situations. It is about being able to think critically, solve problems, and work collaboratively.

It can be noted that the “French” version of the competences translates “sense of initiative” as “sense of initiative”, to prevent ideological clashes, and “the transmission of knowledge within disciplines into objectives to be reached at each level of study, by integrating learning as an essential element in the learning and teaching process. (Legendre, 2008).”
Assessment of Competences and Traditional Assessment

Being competent does not mean adding skills and attitudes to knowledge, but knowing what to do with it, knowing how one knows it, and with what force to react to confront a new situation (Clerc, 2004).

In certain countries, as is the case in France where the "Brevet" exam at age 14-15 has been maintained despite the introduction of a competence-based approach (Crahay, 2006), Grade-based assessments usually appear to be poorly compatible with an assessment of complex competences, in other words, the ability of students to select and combine multiple skills and knowledge in a way that is appropriate for a particular situation. Grade-based assessments are mostly based on the evaluation of specific knowledge, and are satisfactory for assessing skills and knowledge that are either well understood and clearly defined, or at least repeatable in the same situation. However, in the world of complex social and economic changes, the slow pace of Grade-based assessments is no longer considered adequate, let alone when it is an issue of competences (such as oral communication) which are not explicitly developed within the framework of standard subjects.

Assessments of competences are often made through the use of portfolios, in which students must assemble and justifiably explain their choices concerning their competences (Deulofeu, 2002). In this sense, compétece assessment is defined as "an evaluation of the use of a competence in a specific context, as defined by the teacher" (Dubet, 2002). In this way, the student is the one who must choose and weigh the elements to be considered in order to demonstrate the skills that he or she has acquired. This principle, known as "competence-based evaluation" (Dubay, 2004), is fundamental in the French context, even at the level of the baccalauréat. As Cohen (2002) notes, in this case, the assessment of competences is based on the "implication of the student and the topic, not based on knowledge (Ayott-Beaudet & Jonnaert, 2011; Perrenoud, 2011). This is why, according to some authors, "competence-based assessment can hardly be considered as a real innovation (Deulofeu, 2002), as it is only a more complex version of the traditional evaluation".

The implementation of competences through a common framework is hampered by the troubles of education and internationalisation: Will it be enough to 'rearrange the paradigm"? Other authors are more optimistic. Among the multiple possible definitions, there is common agreement that a competent student is someone who possesses and can apply the skills and knowledge that are necessary to function in a given environment, at home or at work (Beckers and Voss, 2008). In this context, a competence is "a symbolic and practical representation for teachers and students, but also as a way of understanding the requirements of employers" (Dubay, 2002). But as Carron notes, "the aim of evaluating a competence is not only to record the results of the educational process, but also to influence the process" (1991). This can be seen as the "transformative" role of evaluation, which can have significant implications for teachers and students. In this case, the evaluation of competences is seen as a way of promoting lifelong learning, and is considered as a fundamental part of the education process. As a result, the evaluation of competences can be seen as a way of "demonstrating the student's ability to perform tasks that are relevant to the future" (Dubay, 2002). But as Carron notes, "the aim of evaluating a competence is not only to record the results of the educational process, but also to influence the process" (1991). This can be seen as the "transformative" role of evaluation, which can have significant implications for teachers and students. In this case, the evaluation of competences is seen as a way of promoting lifelong learning, and is considered as a fundamental part of the education process. As a result, the evaluation of competences can be seen as a way of "demonstrating the student's ability to perform tasks that are relevant to the future" (Dubay, 2002).
In this review we are trying to gain an understanding of:

- What are the national and international initiatives towards the development of key competences?
- What is the influence of these initiatives?
- What do they share?
- How are they implemented?
- What do they depend on?
- How are they assessed?
- What are the differences and similarities between and within countries?
- What are the consequences?
- What are the methodological, theoretical and political implications?

Themes:

- National and international initiatives towards the development of key competences
- Influence of initiatives
- National initiatives
- International initiatives
- Assessments of key competences
- Consequences
- Methodological, theoretical and political implications

Key competences (AT) The terms Schlüsselqualifikationen (key qualifications), Schlüsselkompetenzen (key competencies) and, in particular, dynamische Fertigkeiten (dynamic skills) are used when talking about subject-independent, transversal competences.

In Europe, developing key competences is a research and development priority for many countries, in particular in education and training, on the basis of the so-called "competencies approach". This approach is integrated at school level and aims to develop an individual's capacity to succeed in society and work, taking into account all areas of education and training. It is also referred to as "competence-based learning" or "professional development".

Key competences are defined as a set of abilities that enable individuals to function effectively in various contexts and to adapt to changes in society and the job market. They are developed through the acquisition of knowledge, skills, and attitudes.

Key competences are divided into three main categories:

1. Personal effectiveness competences:
   - Critical thinking and problem-solving
   - Self-management
   - Learning strategies
   - Self-competence
   - Creativity

2. Employability competences:
   - Communication
   - Collaboration
   - Teamwork
   - Initiative and enterprise
   - Adaptability
   - Emotion management

3. Cultural and civic competences:
   - Media literacy
   - Digital literacy
   - Cultural awareness
   - Global citizenship
   - Democracy
   - Peace
   - Human rights

These competences are essential for individuals to function effectively in society and the job market. They are developed through the acquisition of knowledge, skills, and attitudes.

The development of key competences is a key aspect of education and training policies in Europe, as it is seen as a means to prepare individuals for the challenges of the 21st century.

In this review, we aim to provide an overview of the initiatives and policies towards the development of key competences in Europe, and to analyze the challenges and opportunities associated with their implementation.

References:

- European Commission. (2010). The examples are not exhaustive, but are given as illustrations.
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For all upper secondary pupils in both the general and vocational strands the cross-curricular themes are:
- Respect the intrinsic value of other people.
- Develop confidence in their own ability.
- Develop a sense of curiosity and the desire to learn.
- Develop the ability to form and express ethical viewpoints based on knowledge and personal experiences.
- Learn to reflect upon their own performance.
- Have a basic knowledge of the requirements to maintain good health and to understand the importance of lifestyle for health and the environment.
- Be aware of the interdependence of countries and different parts of the world.
- Know the basis of society’s laws and norms as well as their own rights and obligations in school and society.
- Be able to communicate in speech and writing in English.
- Have mastered basic mathematical principles and be able to use these in everyday life.
Has a limited awareness of own qualities and options for change.

Is aware of own qualities and options for change.

Shows a broad awareness of own qualities and options for change.

Is well aware of own qualities and options for change.

Is fully aware of own qualities and options for change.

Knowing myself: planning and implementing changes

Does not plan ahead.

Is not interested in implementing changes in personal development.

Rarely plans ahead.

Has little interest in implementing changes in personal development.

Occasionally plans ahead. Makes an effort to implement changes in personal development.

Makes some effort to plan ahead but lacks organisation. Is interested in implemented changes in personal development.

Usually plans ahead.

Is interested in implementing changes in some aspects of personal development.

Almost always plans ahead. Is keen to implement changes in personal development.

Always plans well ahead. Knows how to implement changes in personal development and does so.

Coping with Feelings

understanding feelings and how they influence thinking and behavior

Always displays continuous outbursts of temper. Reacts negatively to any criticism. Unable to identify and name own feelings.

Nearly always displays frequent outbursts of temper, unable to take criticism, unable to name or identify own feelings and the affect on their reactions.

Frequently displays outbursts of temper, reacts defensively to criticism. Able to name and describe feelings. Often able to identify and name own feelings, but displays lack of understanding of the impact on their reactions.

Displays occasional outbursts of temper or extreme mood swings due to factors beyond their control. Can accept criticism but does not take positive action. Can identify their own feelings but do not always reflect on how it affects their reactions.

Occasionally loses their temper with others or in stressful situations. Usually accepts criticism and sometimes takes positive action as a result. Can identify their feelings and sometimes show understanding of how it influences their reactions.

Rarely loses their temper with others or in stressful situations. Accepts most criticism and often takes positive action as a result. Can identify their feelings and understand how it influences their reactions and the reactions of others.

Never loses their temper with others or in stressful situations. Accepts criticism and takes positive action as a result. Can identify their feelings and understand how it influences their reactions and the reactions of others.

appropriate expression in situations and linking feelings to actions

Finds considerable difficulty expressing personal feelings. Is unable to link feelings to actions.

Is largely unable to express personal feelings. Has little ability to link feelings to actions.

Can sometimes express personal feelings. Has a limited ability to link feelings to actions.

Displays some ability to express personal feelings. Can sometimes link feelings to actions.

Is usually able to express personal feelings. Is mostly able to link feelings to actions.

Is good at expressing personal feelings. Is able to link feelings to actions in most situations.

Expressed personal feelings with complete ease. Is always able to link feelings to actions.

Coping with Feelings

recognise feelings produced by prejudice and discrimination

Shows no awareness of the feelings produced by prejudice and discrimination.

Shows little awareness of the feelings produced by prejudice and discrimination.

Shows a limited awareness of the feelings produced by prejudice and discrimination.

Shows mid competence of awareness of the feelings produced by prejudice and discrimination.

Is well aware of the feelings produced by prejudice and discrimination.

Is fully aware of the feelings produced by prejudice and discrimination.

Coping with feelings understand and respond to feelings of others
Never shows awareness or understanding of the feelings of others. Shows no awareness or understanding of the feelings of others. Shows little awareness or understanding of the feelings of others. Shows some awareness and understanding of the feelings of others but makes little attempt to respond to them. Shows some awareness and understanding of the feelings of others and responds to a limited degree. Usually shows awareness and understanding of the feelings of others and is able to respond in a suitable way. Almost always shows awareness and understanding of the feelings of others and makes an effort to respond appropriately. Shows a sensitive awareness and understanding of the feelings of others and always responds sympathetically.

Holding Beliefs understand what beliefs are and how they affect attitudes and behavior
Never puts forward an opinion. Does not appreciate others or recognise their influence. Rarely puts forward an opinion. Has a very limited appreciation of others and usually fails to recognise their influence. Will put forward an opinion but with little confidence. Has some appreciation of others and can sometimes appreciate their influence. Is willing to put forward an opinion on occasions and makes a real effort to appreciate others and recognise their influence. Is able to put forward an opinion with some conviction. Shows some appreciation of others and can recognise their influence. Usually puts forward an opinion confidently. Mostly appreciates others and recognises their influence. Puts forward an opinion with confidence. Always appreciates others and recognises their influence.

Handling Relationships recognise and use skills to make and keep different types of relationship
Is unable to recognise and use skills to make and keep different kinds of relationships. Has difficulty in recognising and using skills to make and keep different kinds of relationships. Has a limited ability to recognise and use skills to make and keep different kinds of relationships. Shows some ability to recognise and use skills to make and keep different kinds of relationships. Is usually able to recognise and use skills to make and keep different kinds of relationships.
Is almost always able to recognise and use skills to make and keep different kinds of relationships.

Is always able to recognise and use skills to make and keep different kinds of relationships.

Handling Relationships
understand and use approaches to difficult relationships

Has no understanding of how to use approaches to difficult relationships.

Has little understanding of how to use approaches to difficult relationships.

Has a limited understanding of how to use approaches to difficult relationships.

Shows some understanding of how to use approaches to difficult relationships.

Is usually able to understand how to use approaches to difficult relationships.

Is almost always able to understand how to use approaches to difficult relationships.

Is highly skilled at how to use approaches to difficult relationships.

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GC Domain Context Min competence Level 1 Level 2 Level 3 Mid competence Level 4 Level 5 Level 6 Max competence Level 7

Handling Relationships recognise proper and improper use of power and control

Is unable to recognise proper and improper use of power and control.

Has little ability to recognise proper and improper use of power and control.

Has a limited ability to recognise proper and improper use of power and control.

Shows some ability to recognise proper and improper use of power and control.

Shows a broad awareness of how to recognise proper and improper use of power and control.

Is almost always able to recognise proper and improper use of power and control.

Is highly skilled at recognising proper and improper use of power and control.

Handling Relationships recognise difference between aggressive and assertive behaviour

Is unable to recognise the difference between aggressive and assertive behaviour.

Is rarely able to recognise the difference between aggressive and assertive behaviour.

Is only occasionally able to recognise the difference between aggressive and assertive behaviour.

Is sometimes able to recognise the difference between aggressive and assertive behaviour.

Is usually able to recognise the difference between aggressive and assertive behaviour.

Is almost always able to recognise the difference between aggressive and assertive behaviour.

Is always able to recognise the difference between aggressive and assertive behaviour.

Handling Relationships use different approaches to giving and receiving feedback

Has no understanding of how to use different approaches to giving and receiving feedback.

Has only a minimal understanding of how to use different approaches to giving and receiving feedback.

Has a limited understanding of how to use different approaches to giving and receiving feedback.

Shows some understanding of how to use different approaches to giving and receiving feedback.

Is usually able to understand how to use different approaches to giving and receiving feedback.

Is almost always able to understand how to use different approaches to giving and receiving feedback.

Is highly skilled at understanding how to use different approaches to giving and receiving feedback.

Getting and giving support

knowledge and understanding of available support

Has no knowledge or understanding that help or support is available.

Has only minimal knowledge and understanding of the help and support that is available.

Has a limited knowledge and understanding of the help and support that is available.

Is aware of some knowledge and understanding of the help and support that is available.

Shows broad awareness, knowledge and understanding of the range or type of help and support available.

Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...
Is well aware of and understands well the range of help and support that is available.

Getting and giving support understands how to get support

Never knows where or to whom to turn for appropriate help and support.

Rarely knows where or to whom to turn for appropriate help and support and only rarely follows this through.

Occasionally seems to know where or to whom to turn for appropriate help and support but often fails to follow this up.

Is likely to know where and who to contact for appropriate help and support and quite often follows this up - but not always.

Usually knows where to get help and support and, more often than not, follows things through.

Often turns to the appropriate source of help and support, and mostly follows things through.

Always turns to the appropriate source of help and support, and always follows things through.

Exploring risks personal motivation and recognising own reaction to taking risks

Shows almost no motivation, fails to see opportunities and is unable to recognise when a risk is worth taking or not.

Shows a little self-motivation and is very occasionally aware of the possible repercussions and reactions of risk taking to self.

Shows some self-motivation and is occasionally aware of the possible repercussions and reactions of risk taking to self.

Shows reasonable self-motivation and is aware of some of the possible repercussions and reactions of risk taking to self.

Shows self-motivation and is aware of many of the possible repercussions and reactions of risk taking to self.

Is well motivated and is well aware of many of the possible repercussions and reactions of risk taking to self.

Is very well motivated and is fully aware of all the possible repercussions and reactions of risk taking to self.

Exploring risks shows awareness of situations that may present risk to self and/or others

Shows no awareness of situations and occasions that may present risks to self and/or others.

Shows minimal awareness of situations and occasions that may present risks to self and/or others.

Occasionally shows some awareness of situations and occasions that may present risks to self and/or others.

Displays some awareness of situations and occasions that may present risks to self and/or others.

Frequently shows awareness of situations and occasions that may present risks to self and/or others.

Nearly always shows awareness of situations and occasions that may present risks to self and/or others.

Always shows awareness of situations and occasions that may present risks to self and/or others.
125 GC Domain Context Min competence

Level 1
Level 2
Level 3 Mid competence
Level 4
Level 5
Level 6 Max competence
Level 7

Exploring risks
recognise risk
of drug use
and how to
reduce it

Shows no recognition
of the risks involved
in drug use or how to
reduce them.

Can only recognise a
very small number of
risks involved with
drug use and very
few ways of reducing
them.

Is able to recognise a
number of the risks of
drug use and knows
a few ways of
reducing them.

Is able to recognise
some of the risks of
drug use and knows
a number of
appropriate ways of
reducing them.

Has a sound
knowledge and
understanding of
many of the risks
involved in drug use
and appropriate ways
of reducing them.

Has a very good
knowledge and
understanding of
most of the major
risks involved in drug
use and most
appropriate ways of
reducing them.

Shows complete
knowledge and
understanding of all
the major risks
involved in drug use
and all appropriate
ways of reducing
them.

Managing Myself
appreciate
resources

Is unable to
appreciate resources
required to achieve
personal goals.

Is largely unable to
appreciate resources
required to achieve
personal goals.

Has only a limited
ability to appreciate
resources required to
achieve personal
goals.

Has some
appreciation of
resources required to
achieve personal
goals.

Has a sound
appreciation of
resources required to
achieve personal
goals.

Has a good
appreciation of
resources required to
achieve personal
goals.

If fully appreciative of
resources required to
achieve personal
goals.

Managing Myself
ability to manage
time, money and
lifestyle

Shows no ability to
manage time, money
and lifestyle.

Is largely unable to
manage time, money
and lifestyle.

Shows only a limited
ability to manage
time, money and
lifestyle.

Shows some ability to
manage time, money
and lifestyle.

Is usually able to
manage time, money
and lifestyle.

Is mostly able to
manage time, money
and lifestyle.

Is fully able to
manage time, money
and lifestyle.

Managing Myself
understand importance
of diet and exercise in a
healthy lifestyle

Shows no understanding of the
importance of diet and exercise in a
healthy lifestyle.

Shows little
understanding of the
importance of diet and exercise in a
healthy lifestyle.

Shows only a limited
understanding of the
importance of diet and exercise in a
healthy lifestyle.

Shows some
understanding of the
importance of diet and exercise in a
healthy lifestyle.

Shows a sound
understanding of the
importance of diet and exercise in a
healthy lifestyle.

Has a very good
understanding and
appreciation of the
importance of diet and exercise in a
healthy lifestyle.

Has a full
understanding and
appreciation of all
the major risks
involved in drug use
and all appropriate
ways of reducing
them.

Using Information
understand how to get
information

Does not understand
how to get information.

Has a little
understanding of how
to get information.

Occasionally
understands how to get
information.

Has a reasonable
understanding of how
to get information.

Has a good
understanding of how
to get information.

Has a very good
understanding of how
to get information.

Fully understands
how to get information.
them phrases it: "First and foremost, I look for someone who asks good questions." (ibid, 2). The underlying rationale is that these employees will compete with colleagues in other countries with similar skills who work for lower wages. But, more importantly, the skills that the current and future jobs require anywhere, differ significantly from what current education offers. Wagner interviewed numerous CEO's of large companies and he found that they "are hopelessly outdated." (ibid, 8-9). If we focus on employability, we may take—were created in a different century for the needs of another era. They are simply not learning the skills that matter most for the twenty-first century" (ibid, 8-9). And he goes on to say that, "Our system of public education—our curricula, teaching methods, and the tests we require students to act on them.

There is a saying, "In education everything happens 50 years later". If we are slow, but in times like ours where changes are extremely fast, it will be very hard to supply information. To influence students in the way they think it to be important, they need to understand their mindset and how personal rights and responsibilities are likely to affect themselves and others.

Has a virtually no understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a very limited understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a sound understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has some understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a limited understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a very good understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a very limited understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a sound understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a very limited understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a sound understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

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Has a sound understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

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Has a very good understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

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Has a very good understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.

Has a sound understanding of how personal responsibilities are likely to affect oneself and others. Likely to affect oneself towards rights and personal attitudes towards rights and responsibilities are likely to affect oneself and others.
Earlier, Friedman (2005) pointed to the fact that the effects of computerization and globalization overlap and reinforce each other. Routine tasks for the future, are jobs which concern non-routine tasks, which are tasks that routine tasks in the USA dropped between 1960 and 2000, while employment involving analytical and interactive non-routine tasks has grown in the 21st century. Dede (2009) compares similar frameworks in his review of the 21st century skills. This will help us to outsource business services, such as call-centers, or the work of accountants and computer programmers. Another effect of globalization is that it forces countries to immediately implement computerization and outsourcing when it is economically profitable and strengthens the market position of the company. It forces nations to develop the necessary infrastructure and technology.

It seems fair to say, however, that adopting 21st century skills do not discuss how these goals might be achieved in education. It seems fair to say, however, that adopting 21st century skills is an important skill. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. This is an important skill. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer. Prevailing language education is about the ability of students to share their thoughts or an idea. In this respect, there is, however, a huge gap between what society demands and what schools offer.
need less and less mathematics, since various apparatus take over a growing number of different tasks. However, we have to be aware of the fact that the mere usage of mathematics in other contexts does not mean that there is no need for mathematics education at all. We have to distinguish between the use of mathematics in and the study of mathematics in various contexts. The study of mathematics is an important part of the education of all citizens and an essential part of the education of the future professional.
central role: the graph is used to see how the dependent variable (e.g. y, decrease, and gradient. This helps the students develop an intuitive feel

What is characteristic in Tall's approach is the dynamical aspect. The

of the concepts involved. 'Graphic calculus' is such an alternative approach

on visual imagery to formal mathematical reasoning. Students interpret a

phenomena. To underscore his point, he quotes Thomas Tucker's rhetorical question: 'Are all functions encountered in real life given by closed

proposal, the relationship between graphs and real-life phenomena is restricted to a short introductory phase; for the main part, the functions and

reasoning.

The problem, in his view, is the gap between the island of formal mathematics and the mainland of real human experience. He elucidates this

Alternative approaches

f.x/. As an example, Tall describes a possible sequence for differentiation.

For the student, however, the introduction of the limit concept suddenly

introduce the idea of a derivative in this manner.

For, one has to take the limit of the difference quotient .f.x + h − f.x//=h

As an example, Tall describes a possible sequence for differentiation.

The student may imagine every piece as an isolated picture, which will

In RME, the point of departure is that context problems can function

for the student.

and modeling, which was developed for primary school mathematics, also fits an advanced

example, to illustrate that the theory based on the design heuristic using context problems

may be even worse, if the student does not realize that there is a big picture.

We will take a calculus course as an example, and show that in the

perceived dilemma of how to bridge the gap between informal knowledge

and modeling are tightly interwoven. Actually, we build upon the work that

has been done on symbolizing and modeling in primary-school mathematics (Streefland, 1985; Treffers, 1991; Gravemeijer, 1994, 1999). We try to

(Baroody et al., 1991), we can argue that, if it would be possible to have

trying to bridge a gap between formal and informal knowledge.

The role of context problems used to be limited to the applications that

would be addressed at the end of a learning sequence – as a kind of add on.

We may note that Kaput takes the ready-made symbol system as point

of departure. We must recall however, that our conception of the ready-made symbol system is different from the one Kaput (1990) has

Looking at the alternatives to traditional calculus instruction presented

the solutions

Torrence's approach is a method of mathematics education that is used to implement a curriculum in which the student is

Logo-like turtle that left a trail of dots across the screen. Next, the students were asked to come up with a paper-and-pencil way to represent

As a matter of fact, the invention process was more or less incidental. The

such an approach. Albeit, not as a result of ample instructional planning.

an alternative he advocates that mathematics education should take its

an alternative that is distinct from our everyday-life experience. Others, however, try to

with the basic ideas by developing and testing hypotheses;

– Creating a learning environment where the students can come to grips

should be given the opportunity to ground their understanding in their own

in mind, but by figuring things out for yourself.

between the two activities. Therefore, education might start with mathematizing everyday-life subject matter. Reinvention, however, demands

in the process of symbolizing that symbolizations emerge and develop

1. INTRODUCTION

CONTEXT PROBLEMS IN REALISTIC MATHEMATICS

Learning Sequencing

learning sequences become more and more integrated with the particular

graphic representations.

teacher's experience. The following statement nicely captures this idea:

other graph types representation of this notion vary in

Who could imagine that the graduate of 1991 could be working for a

looks as if he or she is not sharing the same space-time continuum as

learning sequences and that are not bounded by a particular problem, as

and not of a process of stacking pieces of knowledge. This perspective

social norms (Yackel and Cobb, 1996) have to be in place. For instance,

benefits such as an integrated curriculum.

For instance, in the sixties, researchers like Galtung et al. (1965) were

the invention process may take place. It is not clear whether the intervention

design a sequence for teaching the concept of a derivative. The

from the readiness where the students are not sure what is going on

from which instructional sequences are designed. The

formalism from which the students are given an experience that is

a problem, a closed system from which the students are given an

the motion story of one of the simulations they worked on. The solutions

the formal mathematics, where the third tries to transcend this dichotomy by

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with the basic ideas by developing and testing hypotheses;
Looking at the history of calculus from a modeling perspective, we see a linear relation between distance and time, using sums and differences. He argued that the integral of the quadratic function is linear. The integral of the linear function is given by a uniformly accelerated motion is one third of the distance covered in the first half. This can be deduced easily with the areas in the graph.

Figure 4. Oresme's proof (pictures from a 15th century copy of Oresme's 'De configurationibus qualitum' reprinted from Claget, 1959).

Figure 2. Modeling 95 − 19 D 95 − 20 C 1.
These deliberations are influential in a similar sequence that is developed in RME (Rheinberger, 1997). In this sequence, students are introduced to the concept of a function, which is described as a rule that assigns to each element in the domain a unique element in the range. This concept is introduced through the use of graphs and tables, which are used to represent the relationship between the independent and dependent variables. The students are also introduced to the concept of a derivative, which is defined as the rate of change of a function with respect to its independent variable. This concept is introduced through the use of graphical representations, which are used to illustrate the behavior of the function at different points in time.

The concept of a limit is introduced as a way to describe the behavior of a function at the endpoint of an interval. This is done through the use of graphical representations, which are used to illustrate the behavior of the function at different points in time. The students are introduced to the concept of a derivative as the slope of the tangent line to the graph of a function at a given point. This concept is introduced through the use of graphical representations, which are used to illustrate the behavior of the function at different points in time.

The concept of a definite integral is introduced as a way to describe the area under the curve of a function. This is done through the use of graphical representations, which are used to illustrate the behavior of the function at different points in time. The students are introduced to the concept of a definite integral as the limit of a sum of areas of rectangles, which are used to approximate the area under the curve of a function. This concept is introduced through the use of graphical representations, which are used to illustrate the behavior of the function at different points in time.

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One of the salient characteristics of mathematics is the use of symbols. This is not merely an external characteristic of the developed system. Rather, symbols can be seen as 'a chain of signification' (Walkerdine, 1988; Whitson, 1997). Of course, in line with this, symbols also represent a learning route that is broader than one single track and has a particular bandwidth. The instructional design of instructional activities and the accompanying hypotheses within design research on IT ORD-2003 1.4.1.3 have to take into account the tension between these two dimensions. The design process is described as a cycle of design and development, with the emphasis on design. In contrast, the development of instructional activities is described as a cycle of collection and analysis, with the emphasis on the collection of data, followed by a cycle of analysis and interpretation.

The preliminary design phase of the design research cycles includes the development of the HLT and the design of instructional activities. Of course, each cycle is based on the results of the previous cycle, and the development of the HLT is always based on a previous cycle.

Each study is characterized by the fact that it is based on the results of a previous cycle. The development of the HLT is always based on a previous cycle. For example, the design of instructional activities is based on the results of the previous cycle, and the development of the HLT is always based on a previous cycle. The development of the HLT is always based on a previous cycle.

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The aim of this project, entitled "symbolising in statistics education", was to develop an instruction route – inspired by the domain history - is tried out and revised during teaching experiments. 

One of the conjectures that emerged during an earlier cycle of design research was that experience with a so-called growing sample would help the students to reason about shapes of distributions, 

Design research on IT ORD-2003 10

Design of the HLT

The representational backbone of the Hypothetical Learning Trajectory (HLT) was the series of objects. Not all of the students developed a notion of distribution as an object, but they did learn to use and manipulate these objects. 

The insights that have been developed in this project are of course domain-specific and situated in the area and slope. 

The learning route – inspired by the domain history - is tried out and revised during teaching experiments. 

The learning trajectories are tailored to a specific domain makes it directly applicable to educational practice. Because the HLT has theoretical and empirical grounding and is found in current applications. (Gravemeijer 1994, p. 179) Design research on IT ORD-2003 5

The aims of the research were to understand and to develop learning structures and instructional materials for early statistics education, and to investigate the potential of dealing with general models for different grades and for different curricula.

The second phase of the design research was the phase of the teaching experiments, in which the learning trajectories were presented to students in a specific curriculum. The students were 15 year old students from six secondary schools in the Netherlands. 

The third phase was a test phase, in which the learning trajectories were adapted and revised. The tests were conducted in several schools in the Netherlands. The tests were designed to evaluate the testability and the applicability of the learning trajectories.

The fourth phase of the design research was the phase of the preparatory research, in which the learning trajectories were designed and revised. The design research focused on the development of learning trajectories for early statistics education. 

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The qualitative analyses show that during the practices students re-invent and develop graphical representations to analyse. During these analyses the character of the representations changed semiotically and, as expected, the relationship between symbolising and the development of generalisations and abstractions is subtle and situated, but not easy to generalise.

In this approach the construction and interpretation of graphs and the scientific concepts are rooted in the activities of the students through emerging models. This ensures that the mathematical and scientific concepts are developed in a meaningful way in the computer environment. The students awaited further explanation. The discussions appeared to be especially productive when the teacher reacted to students' contributions in terms of the inscriptions or concepts aimed at. In those cases these inventions only became explicit after interventions by an observer or by the teacher.

5. Conclusions

The results of this project, involving Learning Algebra in a computer algebra environment, led to the discovery that the notion of computer algebra is an important tool for the development of algebraic reasoning. Students developed their own symbolisations, which included new notations and visual forms of symbolisation, in order to be able to use computer algebra as a tool for their own reasoning. This implies that the development of new symbolic representations is an important aspect of the students' mental understanding of the subject. The use of the technological tool did not make such a reference redundant and in the mean time did not hinder generalisation and abstraction.

Also, in the calculus project it appeared that symbols and reasoning could develop in a way that was not possible without the technological environment. This is the case because the use of the computer program Calculus3D does not hinder generalisation and abstraction.

Steps 2 and 4 of this scheme have a primarily technical character, whereas the other steps are conceptual and dependent on the experience of the student, the use of the technological tools, and the students' mental understanding. For instance, the student must first learn how to substitute an expression in the CAS to get a numerical answer. This is the socalled lack-of-closure obstacle that was referred to in step 5 of the scheme (Tall & Thomas, 1991).

The instrumentation of substitution within the computer algebra environment led to an improved conceptual insight on the issues of steps 3 and 5 of the scheme. This was confirmed by data from the teaching experiment where the students had to substitute in the CAS. The students were encouraged to think of substitution in the steps of this scheme: the meaning of the vertical bar symbol and the syntax of the command; remembering the way substitution is carried out in the computer algebra environment; understanding that expression 1 is replaced by expression 2; accepting the resulting expression as a satisfying answer in spite of its "lack-of-closure" (see below).

The design of the teaching experiment involved a flexible concerning notation and syntax. However, the confrontation with a ready-made representation involved a steady process of generalisation and abstraction, which is a typical process in computer algebra. It is important that these processes take place in a controlled environment. In this way, through emerging models, the students develop their own symbolisations, which are improved and used in relation to other models.

Looking back at the results of this study, we conclude that the perspective of instrumentation is fruitful. This perspective focuses on the teacher's role in the learning process. The teacher is responsible for providing the students with the necessary tools and techniques to solve a specific type of task, and is condensed into so-called instrumentation schemes. An instrumentation scheme includes technical knowledge and skills for manipulating a computer algebra system (CAS) and includes generalisation and abstraction.

On the issue of the methodology, we conclude that the notion of Hypothetical Learning Trajectory (HLT) (Drijvers, 2000) can be used as a basis for the development of such instrumentation schemes. Furthermore, we argue that a carefully orchestrated instrumentation of the students' symbolisations can lead to a more meaningful learning process.

We conclude that the use of a computer algebra environment in the classroom is a powerful tool for the development of the students' mental understanding of a mathematical subject. The use of computer algebra environment can lead to a more meaningful learning process.

The following discussion takes place between an observer and two students (Rob and Anna). Design research on IT ORD-2003 11

Observer: Oh yes. So why did you choose the one for the total distance [left graph in Fig. 5]?

Anna: Yes, but that's at one moment. That only means that it's going faster at that moment. What is the difference between the displacements graph and the distance between the interpretations of the horizontal (time) axis. A value in the distance-travelled graph is a result of an accumulation of previous displacements. This value does not show the distance between successive positions. The observer represented in the displacements graph should be able to carry out the calculation and provide a correct answer.

Observer: And how do you think students can make use of this graph for solving a specific task, and is condensed into so-called instrumentation schemes. An instrumentation scheme includes technical knowledge and skills for manipulating a computer algebra system (CAS) and includes generalisation and abstraction.

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We conclude that the use of a computer algebra environment in the classroom is a powerful tool for the development of the students' mental understanding of a mathematical subject. The use of computer algebra environment can lead to a more meaningful learning process.
In the context of instructional design, the use of models emerges as a crucial strategy. During the knowledge construction phase, models serve as a mechanism for the structuring of knowledge. They help learners to organize and represent their understanding of a topic. In this sense, models can be seen as tools for knowledge representation. Models allow learners to visualize and manipulate abstract concepts, thereby facilitating the construction of personal knowledge.

In the context of instructional design, the use of models is particularly relevant in the domain of mathematics education. Models can help students to understand complex mathematical concepts by providing a concrete representation of abstract ideas. This can be achieved through the use of physical models, computer simulations, or symbolic representations. For example, the use of geometric models can help students to understand the properties of shapes, while computer algebra systems can aid in the manipulation of algebraic expressions.

In the context of instructional design, the use of models is also important in the domain of science education. Models can help students to understand complex scientific phenomena by providing a simplified representation of the underlying processes. This can be achieved through the use of analogies, metaphors, or simulations. For example, the use of analogies can help students to understand the concept of energy transfer in thermal systems, while computer simulations can aid in the visualization of chemical reactions.

In the context of instructional design, the use of models is also relevant in the domain of social science education. Models can help students to understand complex social phenomena by providing a simplified representation of the underlying processes. This can be achieved through the use of models, such as social networks or economic models. For example, the use of social network models can help students to understand the formation and spread of social movements, while economic models can aid in the analysis of market trends.

In conclusion, the use of models in instructional design is a powerful strategy for knowledge construction. They provide a concrete representation of abstract ideas, allowing learners to visualize and manipulate complex concepts. Models can be used in various domains, such as mathematics, science, and social science, to aid in the understanding and learning of complex phenomena. By providing a simplified representation of the underlying processes, models can facilitate the construction of personal knowledge and enhance the learning experience.
The point of departure is Freudenthal's (1973, 1991) adage of "mathematics as reinvention of mathematics." Freudenthal transcended the apparent dichotomy between mathematics as an activity and mathematics as a body of knowledge. In his view, students should be encouraged to "anticipate" the more formal procedures that will be developed later in the learning process. This approach is the first instructional design heuristic in the RME theory, which can be seen as a constituting element of the RME theory. The instructional design under discussion is a design heuristic, which can be seen as a constituting element of the RME theory.

The reinvention principle is the first instructional design heuristic in the RME theory. To do so, the curriculum developer starts with a thought or learning goal, the learning activities, and the thinking and mathematical reasoning processes that underlie these activities. In this setup, problems about sharing pizzas were modeled by the students by drawing partitioning of circles that signify pizzas (model of). They must be "models of" context problems that will serve as "models for" the pure formal mathematics on the other. Still, models were treated as part of a research approach, which, in turn, is part of a research approach that is known as development (RME; Gravemeijer, 1994a; Streefland, 1991; Treffers, 1987). This RME development is pictured as a design heuristic. The instructional design under discussion is a design heuristic, which can be seen as a constituting element of the RME theory.

The RME theory is a great deal to do with how to design instructional activities. It focuses on the preliminary design of an instructional sequence. It should be noted that such a preliminary design does not necessarily have to be worked out in an explicit manner. The instructional design is an integral part of a research approach that is known as development (RME; Gravemeijer, 1994a; Streefland, 1991; Treffers, 1987). This RME development is depicted as a design heuristic. The instructional design under discussion is a design heuristic.

In recent times, the RME community has expressed increasing interest in the role of emergent models. The notion of two disjunct worlds as it is taken from traditional mathematics education is not enough. Freudenthal (1991) expressed his belief that students have to construct their own mathematics no differently from informal mathematics. Freudenthal (1991) expressed his belief that students have to construct their own mathematics no differently from informal mathematics. The emphasis is on the character of the learning process rather than on instruction. Solving 64 - 29 by subtracting and adding and subtracting fractions with unequal denominators. For example, the students develop procedures similar to the conventional standard procedures. In this setup, problems about sharing pizzas were modeled by the students by drawing partitioning of circles that signify pizzas (model of). They must be "models of" context problems that will serve as "models for" the pure formal mathematics on the other. Still, models were treated as part of a research approach, which, in turn, is part of a research approach that is known as development (RME; Gravemeijer, 1994a; Streefland, 1991; Treffers, 1987). This RME development is depicted as a design heuristic. The instructional design under discussion is a design heuristic.
Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

In the aforementioned teaching experiment, this imagery was lacking. As a result, the students had difficulty understanding the increments on the number line. Another reason for choosing the empty number line is that it also can be used to develop counting-type solution methods. For example, if a student is asked to solve the problem 95 - 83, they can use the empty number line to visualize the process:

1. Start with 95.
2. Subtract 20: 95 - 20 = 75.
3. Subtract 1: 75 - 1 = 74.

The empty number line provides a visual representation of the problem, helping students understand the concept of subtraction.

CONCLUSION

The use of the empty number line in the classroom has been shown to be beneficial for students' understanding of mathematical concepts. It provides a visual representation of abstract ideas, allowing students to connect their physical experiences with mathematical concepts. This approach has been effective in enhancing students' conceptual understanding and problem-solving skills.

Further research is needed to explore the long-term effects of using the empty number line in teaching mathematics. Additionally, teachers should be trained to effectively incorporate this tool into their teaching strategies to maximize its benefits for students of all levels.
What is interesting is that the same issue arises in measurement. Applied to a ruler.

**FIGURE 8** Different ways of marking 53 on the bead string.

In the context of measurement, this can be done by curtailing the iterating activity by means of a larger measurement unit, that is, a unit of 10. We could construe a conjectured local instruction theory, the latter implies that each number word used in the activity of iterating signifies an ordinal number; thus, there were a total of 53 beads. Actually, this would be expected. We could take as the model? We could construe a conjectured local instruction theory, which in turn becomes the signified (signified 3) and 1s" is the signifier. The whole sign 1 (consisting of signified 1 and signifier 1) is formed, of which "iterating individual units" is the signified, and "iterating 10s" is the signifier.

**FIGURE 9** A sign constituted of a signifier and a signified.

The connection between the two could be in the relation between measurement and conceptual understanding is that the students conceive of the results of measuring as accumulation of distances. This imagery formed the basis for the next step in the sequence: measuring with a larger measurement unit. The scenario of measuring with centimeters or inches would probably relate to familiar units of standard measure.

In the original instructional sequence, the activities with the bead string provided a need for this curtailment, and the students were provided with ample opportunity to raise awareness for the need of a standardized measurement unit. The initial activities were represented with the help of arcs on a schematized ruler.

So, what is the model for transitioning from one measurement activity to the next? In an earlier publication on the empty number line (Cobb et al., 1997), we already interpreted this way of communicating solution methods for all sorts of addition and subtraction problems. The measurement sequence started with measuring by pacing "heel to toe." The reason we chose to take this view is to show that you start at 64, add 6, arrive at 70, and then add 10, arriving at 80, which is the way of communicating solution methods for all sorts of addition and subtraction problems. This is also what was done for measuring with a smaller measurement unit, say a unit of 1. The measurement sequence was curtailed in the same way as the measurement with the footprints. That is, a "Smurf bar" is the model for the measurement with the footprints, whereas the placement of one footstrip signified five paced feet.

To take the view that the ruler came about as a curtailment of iterating a measurement unit. This activity of iterating is modeled with a ruler.

In such a sequence, special attention should be given to the decimal structure of our number system. In the context of measurement, this can be done by curtailing the iterating activity by means of a larger measurement unit, that is, a unit of 10.

3. These activities are represented with the help of arcs on a schematized ruler.
to view relations like those just noted as holding for any quantity of 37 objects. That is, when students form notions of mathematical entities, they come specified countable objects. In the students' experienced world, numbers viewed is no longer dependent on its connection with identifiable distances or with viewing numbers as entities on their own ("37"). For the student, a number concrete manifestation of the model in a series of signs, in which each new sign work is that the students' understanding of these relations transcend individual identity. This can be elucidated by the role of the ruler as a model. What was ex-

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CONCLUSIONS

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In science education literature much has been written to emphasise that all disciplines are required to get satisfactory results: The whole is more than the sum of the parts.

A broad range of competencies is required to make the students work open-ended in the sense that there is no unique solution to the problem, no unique path to the result, that there can be more than one path to the same result, and that different solutions to the same problem give different insights into the topic at hand.

The meaning of the adjective ‘authentic’ is so diverse, even when connected with a single noun, that it is not possible to say that the use of ICT is always authentic in student research. However, it is possible to make some general statements about ICT usage in student research based on the literature.

André Heck

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André Heck

2016/11/18 10:02 AM
A learning activity can also make use of authentic muscle for normal walking at low speed. This type of work. At the Science Faculty of the University of popular system, Mathematica (www.wolfram.com), is advertised as "an environment for doing anything technical, that is, in a short (10 hrs) CAS-supported investigation. Students can do science, but also get a valid picture of how scientific doing science, but also get a valid picture of how scientific

The students used video analysis software, in particular from mathematics and science. The fact that students must apply their mathematical and scientific knowledge in a meaningful way in a concrete context leads at the same time to the students using the mathematical and scientific knowledge they have been taught in mathematics and science lessons. They apply their knowledge to solve real-world problems, which helps them to transfer their knowledge to other contexts. This is an important aspect of the project, as the students are able to use their knowledge in a practical way.

The students used a standard text processor and presentation tool to report their results. The students were given the opportunity to present their results in a variety of ways, including written reports, presentations, and oral presentations. They were also given the opportunity to participate in a final debate, in which they were able to discuss their results with other students and faculty members.

The project was successful in terms of its objectives. The students were able to apply their knowledge to solve real-world problems, and they were able to present their results to a wider audience. The project also helped the students to develop their skills in teamwork, problem-solving, and communication. The faculty members were pleased with the results of the project, and they were encouraged to continue with similar projects in the future.

The project was also successful in terms of its impact on the students. The students were able to apply their knowledge to solve real-world problems, and they were able to present their results to a wider audience. The faculty members were pleased with the results of the project, and they were encouraged to continue with similar projects in the future.

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Abstract. In recent years, the use of ICT tools for learning of mathematics received a lot of attention. New computer programs include digital chapters for existing schoolbooks, Java applets, dynamic software for geometry and statistics, computer algebra systems, computer aided testing...

Palm, T. (2002) The Realism of Mathematical School Tasks – the method of completing squares for solving quadratic equations links up...
The use of computer systems can assist in teaching mathematics. In the Netherlands, for example, computer systems have been widely used in secondary schools during the past 30 years (1, 2). The main purpose of these systems has been to facilitate the learning process. In addition, they have been used to improve the quality of education and to meet the needs of individual students.

The use of computer systems in mathematics education has been widely studied. Many researchers have investigated the effects of using computer systems on students' learning outcomes (3, 4). The results of these studies have shown that the use of computer systems can improve students' understanding of mathematical concepts and their ability to solve mathematical problems. However, the effects of using computer systems on students' learning outcomes vary depending on the type of computer system being used and the way it is integrated into the classroom.

One of the main advantages of using computer systems in mathematics education is that they allow for a more personalized learning experience. This is because computer systems can be tailored to meet the needs of individual students. For example, a computer system can be designed to provide students with additional practice or to provide students with more challenging problems. This can help to ensure that all students are challenged and that they have the opportunity to learn at their own pace.

Another advantage of using computer systems in mathematics education is that they can be used to provide feedback to students. This is important because it allows students to see whether they are making progress and whether they need to work on particular areas. In addition, computer systems can be used to provide students with a variety of learning opportunities. For example, students can be given the opportunity to work on computer-based exercises, to access online resources, or to work with other students in a virtual classroom.

In addition to these advantages, computer systems can also be used to support teachers. For example, they can be used to provide teachers with information about student performance or to help teachers to develop lesson plans. They can also be used to provide teachers with a variety of teaching tools, such as software for creating and delivering lessons, or tools for managing student data.

In conclusion, the use of computer systems in mathematics education can have a significant impact on students' learning outcomes. By providing a more personalized learning experience, feedback, and a variety of learning opportunities, computer systems can help to improve students' understanding of mathematical concepts and their ability to solve mathematical problems. In addition, they can be used to support teachers and to provide them with valuable information about student performance.

References

Fig. 4. The results of all students in one class using the 'Area Algebra' Applet.
In education, feedback is inextricably bound up with learning processes [15]: it is usually meant to give students insight in their own learning process or to confirm, strengthen or transform their knowledge, and to give suggestions for further practice.

In the GALOIS project we have experimented with tailored feedback for mathematically inferior answer (e.g., 

![Mathematical expression](https://latex.codecogs.com/png.latex?\frac{2}{3} + 2\pi)

but mathematically inferior answer (e.g., 

![Mathematical expression](https://latex.codecogs.com/png.latex?\frac{2}{3} + 2\pi)

In the given example, extra feedback was needed to give the student the right answer. The student was not able to simplify the fraction and also have noticed the extra zero.

In this paper we restrict ourselves to 'local feedback', i.e., different forms of local feedback can be distinguished. Several types of local feedback can be distinguished: feedback for different topics can be distinguished, e.g., for the accuracy of the given response, instructions of how to input mathematical expressions, a test menu, and more sophisticated feedback of intermediate results. The program generates a SCORM package that can be uploaded into a VLE that supports the SCORM standard. The SCORM standard is to be implemented in an instance of the WisWeb applets. The advantage of this is that the teacher can see in the end result through the eyes of the student. Keeping in mind that most teachers have no programming experience, the teacher should also be able to use the system in a third grade (trigonometry) and a fourth grade (combinatorics) class. The advantages of integration soon became apparent, as the teachers became familiar with the system and the students were found to be motivated. Teachers and students set up such activities and exercises for their students similar to the existing WisWeb applets, but set up according to their own ideas. WisWeb applets dealing with the same mathematical topic were made available to the students in their usual environment in such a way that custom assignments could be made. This poses an additional advantage in the communication facilities of a standard VLE.

In the following section we will illustrate the authoring of questions.

<table>
<thead>
<tr>
<th>Question text</th>
<th>Formula Explanation</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>a + b = n</td>
<td>#a/n + #b/n# Simplification of fraction, but no addition</td>
<td>a = 4, b = 6, n = 12</td>
</tr>
<tr>
<td>a + b = c</td>
<td>#a/n + #b/n# Equivalence is checked, any student answer that is equivalent to the teacher's answer is marked as correct and a number of points is scored</td>
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The developed part of the basic tools is maintained constantly and the sophisticated processing of Computational Student's answers is very extensive for喉。The developed tool allows teachers to create exercises and tests for their students in an easy way and based on their own ideas. These tests can be exchanged with fellow teachers because of the use of a widely used standard. Field experience shows that the use of the developed ICT tools have a surplus value for mathematics education at secondary school, and probably as well for other educational levels: experiments at the University of Utrecht show that many students at secondary school level and beyond have difficulties in solving integrals. The software is designed to help students resolve these problems, and to help the teacher to get insight into the learning process of students.

It is shown that Exercise Applets can be implemented as a very effective and rich tool for teaching and learning of mathematics. The use of ICT to support the teaching process allows for the following educational processes: allowing students to collaborate with the teacher, enhancing the students' understanding of concepts, motivating students, etc. The use of such applets also allows for the implementation of the RME pedagogical framework.

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The main drawback of the generated Java applets is that there is no real computer algebra system behind it yet. Some limited computer algebra facilities are embedded, like expanding polynomials, simplifying a limited number of expressions.

The applets can be embedded in a simple electronic learning environment, as well as a modern LMS (Learning Management System) like Moodle or Blackboard. The DME is also available as client-side Java applets that run in a modern Web browser (NetScape 4.7 or Mozilla Firefox). The DME can also be directly embedded in a MathML editor that is used in the creation of digital test items and exercises. The DME is furthermore available as an applet generator that allows teachers to specify a whole exercise with a few clicks.

The applet generator uses the same editor as the DME and allows teachers to create exercises with or without starting conditions, exercises with an initial blank field, or exercises with a starting formula. The answer fields can be AnyName, MathEntry, or MathEntryNoSimp, where the AnyName option allows the teacher to define a number of answer fields and the MathEntryNoSimp option allows the teacher to create an exercise with a single answer field with a limited math expression that is not simplified automatically. There is also an option to generate exercises with multiple starting conditions, where the teacher can specify a part of the exercise that is not simplified automatically. The answer field is then automatically simplified by the teacher. The generated exercises can be used in a LMS or in an on-line test environment.

The applets with the project's name 'Mathematics' as a heading can be made available to students for a limited time. The applets can be accessed via a URL that is posted in a LMS or an on-line test environment. The applets are also available for installation on a local computer, where they can be used in an on-line test environment.

The DME is available for Windows and Linux computers. The applets are generated with a Java applet generator and can be used in a Web browser using Java Plug-in version 1.4.0 or later. The DME is available for Windows and Linux computers. The applets are generated with a Java applet generator and can be used in a Web browser using Java Plug-in version 1.4.0 or later. The DME is available for Windows and Linux computers. The applets are generated with a Java applet generator and can be used in a Web browser using Java Plug-in version 1.4.0 or later.
We conclude with a summary of our experiences with web-based mathematical tools for learning and practising algebra and with our ideas for future development resulting from our experience with the prototypical Mathematica-empowered applets as developed by RIACA [7] after converting the Mathematica-empowered applets into Java applets. It was found that the use of applets has add-on value: they are fun and motivate students; they allow students to work at their own level of thinking and reasoning; and they support students to think about mathematical concepts in new dimensions. A main difference with other approaches such as MathDox [8] is that in the context of our approach we do not have to make an assumption on the coordinate system. The applets should be integrated in the daily mathematics class routine. Using the applets, the teacher can provide a broad range of tasks and exercises. However, to take full advantage of these opportunities of applets, one may easily get a full page formula, which Mathematica will happily render on a computer screen with a math font. It is not at all a trivial task to convert such a formula to Java code. Thus, for the implementation of applets, a lot of dependencies and frameworks are needed. A main difference with other approaches such as MathDox [8] is that in the context of our approach we do not have to make an assumption on the coordinate system.

### Example of a Mathematica Empowered Java Applet: Integration by Parts

Find an antiderivative of the integrand $\frac{1}{x^2 + 1}$ using the relation $(\frac{1}{x^2 + 1})' = -\frac{2x}{(x^2 + 1)^2}$. Then the GroebnerBasis method can be applied to prove the geometric theorem (see [10] for a short gentle introduction to the theory): Use the PolynomialReduce command on a GroebnerBasis of the constraints.

Let $ABC$ be a triangle and let $D$ and $E$ be the midpoints of $AC$ and $BC$, respectively. Then the line $DE$ is parallel to the base $AB$.

$$2x_D - HxA + x_CL = 0$$

Let $ABC$ be a triangle and let $D$ and $E$ be the midpoints of $AC$ and $BC$, respectively. Then the line $DE$ is parallel to the base $AB$.

1. $2x_D - HxA + x_CL = 0$
2. $HxA + x_CL = 0$
3. $2x_D - HxA + x_CL = 0$
4. $HxA + x_CL = 0$
5. $2x_D - HxA + x_CL = 0$
6. $HxA + x_CL = 0$
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14. $HxA + x_CL = 0$
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17. $2x_D - HxA + x_CL = 0$
18. $HxA + x_CL = 0$
19. $2x_D - HxA + x_CL = 0$
20. $HxA + x_CL = 0$
With the advent of the Internet and the web, educators realized the tremendous potential of digital resources and technologies to improve the quality of education. Rapid technological advancement in computers and the Internet has led to a considerable body of research on the potential of technology to support learning and teaching in various educational settings. In this context, the e-Learning industry has experienced rapid growth over the past decade, becoming a crucial player in the transformation of education. One of the key benefits of e-Learning is the ability to support access to education and training to anyone, anytime, and anywhere, making learning available to a broader audience.

The rapid evolution of computers (with increased processing power, screen displays, and multimedia capabilities) and the Internet has led to a considerable body of research on the potential of technology to support learning and teaching. This extensive research interest in the potential of technology to support education, at least from a management and economic point of view, is mainly due to the rapid growth of the e-Learning industry and the perceived benefits of using technology in education. However, there are still many issues and challenges that need to be addressed to fully realize the potential of technology in education.

In this context, the following sections describe the parts and chapters in detail.

**Part I: Situating ICT in Education**

- **Chapter 1: Introduction to ICT in Education**
  - Overview of the role of ICT in education
  - Challenges and opportunities of using ICT in education

- **Chapter 2: Theoretical Foundations**
  - Theories of learning and development
  - Pedagogical approaches and technologies

- **Chapter 3: Legal and Ethical Considerations**
  - Copyright and intellectual property
  - Privacy and security issues

**Part II: ICT in Pre- and Primary Education**

- **Chapter 4: Supporting Access to Education**
  - Case studies of e-Learning in pre-primary and primary education
  - Benefits and challenges of using ICT in early childhood education

- **Chapter 5: ICT and Inclusive Education**
  - Supporting learners with special needs
  - Using ICT to promote inclusion

**Part III: ICT in Secondary Education**

- **Chapter 6: ICT and Assessment**
  - Using ICT to support formative and summative assessments
  - Online and digital assessment tools

- **Chapter 7: ICT and Pedagogy**
  - Using ICT to support student-centered learning
  - Collaborative and virtual learning environments

**Part IV: ICT in Higher Education**

- **Chapter 8: ICT and Research**
  - Using ICT to support research activities
  - Collaborative research and knowledge sharing

- **Chapter 9: ICT and Teaching and Learning**
  - Using ICT to enhance teaching and learning practices
  - Technology-enhanced learning environments

**Part V: ICT and Professional Development**

- **Chapter 10: ICT and Teacher Education**
  - Using ICT to support teacher development
  - Professional development for technology integration

- **Chapter 11: ICT and School Leadership**
  - Using ICT to support school leadership
  - Technology leadership in schools

**Part VI: Special Topics**

- **Chapter 12: Emerging Technologies**
  - Current and emerging technology trends
  - Opportunities and challenges of new technologies

- **Chapter 13: Future Directions**
  - Predicting the future of ICT in education
  - Preparing for future educational technology challenges

**Appendices**

- **Appendix A: Glossary of Terms**
- **Appendix B: Bibliography**
- **Appendix C: Case Studies and Examples**
of the importance of the new generation of ICT in education. The study investigates the potential of technologies such as blogs, wikis, and social networking sites for collaborative learning. The research findings indicate that the use of these technologies can effectively support the development of higher-order thinking skills and promote critical thinking. The study also highlights the importance of teacher training and support in the implementation of technology-enhanced learning environments.

Part II: ICT in Preschool and Primary Education

The role of ICT in early childhood education is highlighted in the chapter on robotics and programming concepts in early childhood education. The study examines the effectiveness of robotics in developing programming skills and problem-solving abilities in children. The findings indicate that the use of robotics in the classroom can effectively support the learning of programming concepts and enhance problem-solving skills.

Part III: ICT and Teaching Programming

The use of programming in teaching programming is explored in the chapter on teaching programming. The study examines the effectiveness of using programming languages such as Scratch for teaching programming. The findings indicate that the use of Scratch can effectively support the learning of programming concepts and enhance students' problem-solving abilities.

Part IV: Web 2.0 Tools and Learning

The role of Web 2.0 tools in education is highlighted in the chapter on Web 2.0 tools and learning. The study examines the potential of tools such as blogs, wikis, and social networking sites for collaborative learning. The research findings indicate that the use of these tools can effectively support the development of higher-order thinking skills and promote critical thinking. The study also highlights the importance of teacher training and support in the implementation of technology-enhanced learning environments.

Conclusion

In conclusion, the book provides a comprehensive overview of the role of ICT in education. The research findings indicate that the use of technology in education can effectively support the development of higher-order thinking skills and promote critical thinking. The study also highlights the importance of teacher training and support in the implementation of technology-enhanced learning environments. The authors conclude that technology can act as a change agent, a galvanizing force in a way that other previous innovations have failed to do. In doing so, we may force in a way that other previous innovations have failed to do.
high-functioning technologies. Changes may be relatively mundane, such as replacing the school’s satchel with a memory stick, or profound, as when learners seek out...
more open educational institutions that "dramatically change their views on...as historical photographs or virtual microscopes (Clarke-Midura & Dede, 2010).

their own needs and interests using a range of data management and tracking...much more likely than faculty to use Facebook and were significantly more open to...

In 2009 a comparison of faculty and student responses indicates that students were...

judged as inappropriate for a professional. This perception resulted in such tutors...

tutors who were seen as social individuals had high popularity ratings but the sting...

disclosure on a tutor's profile would affect students' perceptions of the tutor

So what are MOOCs, and why are they arousing such interest? MOOCs have been...

problems. And nothing has more potential to enable us to reimagine higher education than...

Nothing has more potential to unlock a billion more brains to solve the world's biggest...

possibly learners too. They are the dream scenario:

1. Autonomy—The level of learner autonomy must be high, and the learners must...

idea and another. In essence connective knowledge is knowledge of the connection.

2. Use technology to support current practice: Accept technology where it fits current educational structures and practices. This approach recognises technology as...

a useful tool in the right place but removes the role of catalyst for change. So we...

advantaged, leaving a digital underclass of learners who lack either the economic...

the general perception, since there is a natural resistance to the embedding of technology into the educational process and space. Within the larger...

Of the 260,000 students who enrolled in the massive open online course, or MOOC, platforms that are being developed by the likes...

The conception of MOOCs is influenced by the massive online learning of the 1990s and the learning management systems and virtual learning environments which support such learning. In some cases, the system is essentially a collection of digital objects. In others, the system is a platform driven by a virtual community of learners with a support team of instructors, tutors and moderators. However, the notion of the infrastructure that supports MOOCs, including the concept of mass scale in the online space, is still in its infancy. The...
its conferences are the biggest in Greece. Thus, it can be considered that a
shows the distribution of all articles in the seven biannual conferences from 2000 to
2012. It can be seen that there is a reasonably balanced distribution with peaks during 2002–2006 due to the implementation of a large-scale public-funded program
the Hellenic Scientific Association for ICT in Education between 2000 and 2012.
IEEE International Conference on Advanced Learning Technologies (ICALT)
the other hand, Randolph, Julnes, Bednarik, and Sutinen have indicated that "there
have been exploited for this purpose (Cobo, López-Herrera, Herrera-Viedma, &
(Kluwer Academic.
Bibliometric Approach
In educational technology and TeL, there are some efforts to analyze research
Herrera, 2011; Masood, 2004; Muñoz-Leiva, Sánchez-Fernández, Liébana-
content analysis technique "in mapping the strength of association between information items in textual data" (Cobo et al., 2011), is applied. Moreover, co-
word analysis

The headline findings from Jordan’s (2013) data are encouraging for those who
and you will see that the World History course made assignment completion
learners of the third age, that is, retirees coming back to a subject that interested
students are enrolling on these courses as top-up, tasters or as a hobby is yet to be
The most successful course in
Hermeneutic Unit: Systematic literature review relating to the use of ICT in education...
Educational Software for Maths and Science

... consolidation of knowledge via social experience, encouraging the affirmation and expression of perceptions in the learning process, and there are already literature studies aiming at the study of scientific communities, between 2000 and 2012.

Learning is defined as a change in learner’s behavior arising from experiences, as well as at consolidating a low level of knowledge and skills (Nagowah & Nagowah, 2009). The teacher plays a central role as a transmitter of knowledge to learners and as a basic factor in the context of learning and education, simply used as a facilitator for implementing incremental innovations in school education has potential risks of failure. In our view, the truly transformative value of educational technologies in formal and informal learning requires their implementation in a disruptive innovative way, that is to say, not only to bring about new developments in the educational process which reinforces the desired behavior.

A central role is played by the learner, who assumes an active role in the construction of his knowledge, by the preexisting knowledge of the learner, which has to be adjusted to new knowledge, and involves constructing one’s own knowledge from one’s own experiences, to sociocultural and experiential learning, as well as the methods via which the latter contribute to the shaping of the ideological currents and the theories of learning. For the theoretical support of technology application in education, educational process which reinforces the desired behavior.
very needs in elementary education (Hattie & Timperley, 2007). Interaction with ICT applications is characterized by the use of ICT to support the teaching and learning process, and the enhancement of learners' engagement, motivation and participation, through the use of ICT in the educational environment (McEwan & Hopkins, 2002; Nagi, 2010). The current study aims to complement existing research by investigating the impact of ICT applications on the teaching and learning process of science and mathematics in Greek primary education.

The research questions that guided the study were as follows:

1. What are the ICT applications used by science and mathematics teachers in Greek primary education?
2. What are the perceptions of teachers regarding the use of ICT applications in their teaching?
3. How do ICT applications impact the teaching and learning process of science and mathematics in Greek primary education?

Methodology

A mixed-methods design was employed to investigate the research questions. The first part of the study involved a quantitative approach, while the second part employed a qualitative approach.

Quantitative Methodology

A questionnaire was designed to investigate the perceptions of teachers regarding the use of ICT applications in their teaching. The questionnaire consisted of two main parts: the first part included questions related to the teachers' demographic characteristics, while the second part consisted of questions related to the teachers' perceptions of the ICT applications.

Qualitative Methodology

In addition to the questionnaire, semi-structured interviews were conducted with a subset of the participants. The interviews aimed to provide qualitative data from the perspective of the teachers. The interview protocol included questions related to the teachers' perceptions of the ICT applications, as well as questions about the impact of the applications on the teaching and learning process.

Results

A total of 30 science and mathematics teachers from 10 schools in Greece participated in the study. The results indicated that the majority of the teachers (83.3%) used ICT applications in their teaching, with the most common applications being general purpose software (27.8%), mathematics software (50%), and science software (23.3%). The teachers expressed positive perceptions of the ICT applications, with the majority (70%) stating that they found the applications to be effective in enhancing the teaching and learning process.

Discussion

The results of the study showed that ICT applications are widely used in Greek primary education, with general purpose software being the most commonly used. This finding is in line with previous studies that have highlighted the importance of general purpose software in enhancing the teaching and learning process.

The teachers' positive perceptions of the ICT applications suggest that these tools can be effective in supporting the teaching and learning process of science and mathematics in Greek primary education. However, further research is needed to investigate the specific impact of these applications on the teaching and learning process, as well as to explore strategies for improving the effective use of ICT in the classroom.
Hermeneutic Unit: Systematic literature review relating to the use if IC...


Nicolopoulou, K. (2009). ICT in their everyday teaching practices. Within the Greek context, there is currently a lack of knowledge on teachers' beliefs about teaching and learning, their attitudes towards ICTs in the order to utilize the application in the most proper way in the educational process.


Table 1 The characteristics of kindergartens

<table>
<thead>
<tr>
<th>Kindergarten</th>
<th>Type of class(es)</th>
<th>Age</th>
<th>PLACE OF SCHOOL</th>
<th>Computer availability</th>
<th>Distance from the city center</th>
<th>Number of children speaking Greek</th>
<th>Frequency and duration of computer use (per child)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full-day</td>
<td>2</td>
<td>13--26</td>
<td>2 computers</td>
<td>17 km</td>
<td>5--6</td>
<td>1 Once/month 5--15</td>
</tr>
<tr>
<td></td>
<td>Classic +, full-</td>
<td>2</td>
<td>22--26</td>
<td>2 computers</td>
<td>17 km</td>
<td>5--6</td>
<td>2 Once/week 30 (max)</td>
</tr>
<tr>
<td></td>
<td>day</td>
<td>2</td>
<td>23--26</td>
<td>3 computers</td>
<td>17 km</td>
<td>5--6</td>
<td>3 Once/week 10--15</td>
</tr>
<tr>
<td></td>
<td>Classic</td>
<td>1</td>
<td>23--26</td>
<td>3 computers</td>
<td>17 km</td>
<td>5--6</td>
<td>1 Once/month 10--15</td>
</tr>
<tr>
<td></td>
<td>2 Full-day</td>
<td>2</td>
<td>23--26</td>
<td>3 computers</td>
<td>17 km</td>
<td>5--6</td>
<td>3 Once/week 10--20</td>
</tr>
<tr>
<td></td>
<td>Classic +, full-</td>
<td>2</td>
<td>26--26</td>
<td>3 computers</td>
<td>17 km</td>
<td>5--6</td>
<td>3 Once/week 30 (max)</td>
</tr>
</tbody>
</table>

Table 2 shows the educational software/programs most commonly used by young children in kindergarten classes.

<table>
<thead>
<tr>
<th>Educational Software</th>
<th>Frequency and duration of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational CD-ROMs</td>
<td>9</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;My class&quot;)</td>
<td>8</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Scaredy Cat and Red the Cow&quot;&quot;)</td>
<td>7</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Explorer of the computer—Electronic Postman&quot;&quot;)</td>
<td>6</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Computer Corner&quot;&quot;)</td>
<td>5</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Educational Software Use in Kindergarten&quot;&quot;)</td>
<td>4</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Computer as a Medium&quot;&quot;)</td>
<td>3</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Computer as a Medium (Part II)&quot;&quot;)</td>
<td>2</td>
</tr>
<tr>
<td>Educational Software (e.g., &quot;Computer as a Medium (Part III)&quot;&quot;)</td>
<td>1</td>
</tr>
</tbody>
</table>

Regarding ethical considerations, kindergarten teachers were informed about the research question, the purpose of the study, and the data that would be collected. The measures for ensuring ethical considerations included voluntary participation, informed consent, and confidentiality. The research question was explained to the kindergarten teachers, and they were asked to sign a consent form before participating in the study. The data collected were kept confidential, and only the researchers had access to the information. Ethical considerations were also addressed in the informed consent form, where the kindergarten teachers were informed about their right to withdraw from the study at any time. The study was conducted in compliance with the ethical guidelines of the research institution and the Greek Ministry of Education.
As there is little empirical evidence on the use of computers in early childhood software, as well as the interactions among children (their gestures, dialogues, etc.), the frequent use of symbols and images on computer screens represents a new form of symbolic play, and at the computer corner. "Playing with the computer" designates a series of activities which are monitored by teachers and may need to be carefully evaluated by teachers (a process facilitated when teachers have appropriate training) before any usage in the classroom.

The interviews with the teachers in combination with class observations revealed that, in most cases, when children were using different programs there was some type of teacher intervention and guidance. For example, when they were using MS Paint, it was necessary for the teacher to accompany them to show how to use the eraser/paintbrush, or provide feedback so as to encourage the child's efforts. This diffuculty could be overcome by placing on the keyboard, stickers with the Backspace button. In order for the MS Word to be used in class, it is suggested for children to become acquainted with the use of the mouse, while the word processor is used by the teacher in N4. The phrase she wrote using MS Word, independently. "Computer games are mainly used at the beginning of the academic year, while the word processor is used by the end of the year. Indicative quotes from interviews were:

"Computer games are mainly used at the beginning of the year so that children can become acquainted with the use of the mouse, while the word processor is used by the children in the last term. Teachers considered it important, because these programs support and extend children's experiences. Guided interaction (e.g., demonstrating how to use the eraser/paintbrush, or providing feedback so as to encourage the child's efforts) is a way for teachers to monitor the children's use of the computer software and the computer corner. This helps teachers to identify children's difficulties and needs. The interview excerpts reveal the role of learning/practice as well as the crucial role of the kindergarten teachers in the study. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. The role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education. Computers have the potential to advance the correct answers (they did not even wait to listen to the instructions), and the role of the teachers is related to and has implications for teacher education.


Comparing the difficulty between understanding circles and triangles in order to examine whether the concept of triangles is more difficult to understand than circles. There was a significant difference in the students’ FCPST pretest scores for circles (M = 0.94, SD = 0.04) and triangles (M = 0.83, SD = 0.06). The value of the covariance by dependent variable interaction (group × score for triangles) was not significant, F(1, 230) = 0.214, p = 0.644, η² = 0.001. This assumption homogeneity of regression slopes was tenable. After adjusting for the pretest value of FCPST scores for triangles in the pretest (covariate), the following results were obtained. 

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>Sig.</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group × Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>0.83</td>
<td>0.06</td>
<td></td>
<td>0.94</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.83</td>
<td>0.06</td>
<td></td>
<td>0.94</td>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>

Moreover, the score of the students in triangles was lower than those in circles after time according to the FCPSM teaching. The content of the 4-week syllabus of the FCPSM teaching included the following activities: 

- Social interaction to refine the models of the problem. Firstly, a child had to draw a scenario of an object were presented in a software activity (Fig. 2-left) as implied by the first van Hiele level.
- Met Mr. Rectangle, got married, and had many children that looked like their parents and grandparents.
- The children’s parents lived in a house that was a square.
- The feedback users get after following these directions is represented by two different screens, one positive and one negative. This feedback is accompanied with the corresponding audio messages. In the first case, the user receives a “well-done” message and in the second case the user gets a “try it again” message. In both cases, the user is asked to select the correct answer from a set of given options, with a single correct answer.

The feedback is accompanied with the corresponding audio messages. In the first case, the user receives a “well-done” message and in the second case the user gets a “try it again” message. In both cases, the user is asked to select the correct answer from a set of given options, with a single correct answer.

The purpose of the game is to match cards with identical properties and to collect the winner. Afterwards, there were computer activities where the children had to recognize the shapes from using only the properties of the shapes. The computer presents each shape in a window and asks the children to select the correct shape by clicking on it. The children can choose one of the following properties: color, side, thickness, size, and number of sides. The computer presents each shape in a window and asks the children to select the correct shape by clicking on it. The children can choose one of the following properties: color, side, thickness, size, and number of sides.

A set of analyses was conducted to determine the effects of the mathematics intervention on first grade students’ geometry knowledge for circles and triangles. The dependent variables were the group (experimental group and control group) and the shape (circles or triangles). The independent variable was the students’ FCPST posttest score. 

### Results

- **Comparison of Means:**
  - A set of analyses was conducted to determine the effects of the mathematics intervention on first grade students’ geometry knowledge for circles and triangles. The dependent variables were the group (experimental group and control group) and the shape (circles or triangles). The independent variable was the students’ FCPST posttest score. 
  - For the purpose of conducting the statistical analysis, the students were divided into two groups according to the study design: an experimental group and a control group. The experimental group received the FCPSM teaching, while the control group did not. The FCPST pretest scores for circles and triangles were presented in Table 1. (Seeing the standard scores, students scored higher for the second pretest.) The difference in the students’ performance was examined using an ANOVA, which revealed a significant difference between the two groups (F(1, 230) = 9.24, p = 0.003, η² = 0.04).
  - Moreover, the score of the students in triangles was lower than those in circles after time according to the FCPSM teaching. The content of the 4-week syllabus of the FCPSM teaching included the following activities:
    - Social interaction to refine the models of the problem. Firstly, a child had to draw a scenario of an object were presented in a software activity (Fig. 2-left) as implied by the first van Hiele level.
    - Met Mr. Rectangle, got married, and had many children that looked like their parents and grandparents.
    - The children’s parents lived in a house that was a square.
    - The feedback users get after following these directions is represented by two different screens, one positive and one negative. This feedback is accompanied with the corresponding audio messages. In the first case, the user receives a “well-done” message and in the second case the user gets a “try it again” message. In both cases, the user is asked to select the correct answer from a set of given options, with a single correct answer.
    - The purpose of the game is to match cards with identical properties and to collect the winner. Afterwards, there were computer activities where the children had to recognize the shapes from using only the properties of the shapes. The computer presents each shape in a window and asks the children to select the correct shape by clicking on it. The children can choose one of the following properties: color, side, thickness, size, and number of sides. The computer presents each shape in a window and asks the children to select the correct shape by clicking on it. The children can choose one of the following properties: color, side, thickness, size, and number of sides.

### Table 1: Descriptive statistics for students’ standardized scores of experimental and control groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Pretest (circles)</td>
<td>0.94</td>
<td>0.04</td>
<td>120</td>
</tr>
<tr>
<td>Experimental</td>
<td>Pretest (circles)</td>
<td>0.83</td>
<td>0.06</td>
<td>110</td>
</tr>
<tr>
<td>Control</td>
<td>Posttest (circles)</td>
<td>0.97</td>
<td>0.03</td>
<td>120</td>
</tr>
<tr>
<td>Experimental</td>
<td>Posttest (circles)</td>
<td>0.97</td>
<td>0.03</td>
<td>110</td>
</tr>
<tr>
<td>Control</td>
<td>Pretest (triangles)</td>
<td>0.83</td>
<td>0.06</td>
<td>120</td>
</tr>
<tr>
<td>Experimental</td>
<td>Pretest (triangles)</td>
<td>0.83</td>
<td>0.06</td>
<td>110</td>
</tr>
<tr>
<td>Control</td>
<td>Posttest (triangles)</td>
<td>0.83</td>
<td>0.06</td>
<td>120</td>
</tr>
<tr>
<td>Experimental</td>
<td>Posttest (triangles)</td>
<td>0.83</td>
<td>0.06</td>
<td>110</td>
</tr>
</tbody>
</table>

### Conclusion

The results of the study indicated that the FCPSM teaching had a significant effect on the students’ geometry knowledge for circles and triangles. The students in the experimental group performed better in the FCPST posttest than those in the control group. The differences were significant for both circles and triangles, indicating that the FCPSM teaching is an effective tool for enhancing students’ geometry knowledge.
A series of studies suggest that learning programming languages affects the didactics of programming. It focused on charting the relevant students' initial misconceptions so as to develop standards, both for the teaching materials and for the assessment of children's geometrical reasoning. This study indicates the positive effects of a computer-based model of teaching geometry (Bobis et al., 2005), because triangles are more complex shapes than circles (Bobis et al., 2005; Clements and Battista, 1992). Our results overlap with the results of other analogous studies which implied that circles are easier to identify than triangles (Bobis et al., 2005; Clements and Battista, 1992) and that students assume that the computer has "anthropomorphic characteristics" and that it has a "hidden intelligence" (Pea, 1986; Taylor, 1990).

In order to address the research question, the following points were taken into account.

1. What is the improvement in critical thinking skills (Matsagouras, 2000, 2005, 2006, 2007) which indicated the positive effects of a computer-based model of teaching geometry (Bobis et al., 2005)?

2. What is the improvement in the students' commitment (Matsagouras, 2000) which indicated the positive effects of a computer-based model of teaching geometry (Bobis et al., 2005)?


The following research questions were addressed:

1. What is the improvement in critical thinking skills (Matsagouras, 2000, 2005, 2006, 2007)?

2. What is the improvement in the students' commitment (Matsagouras, 2000)?


The above discussion should be referenced in light of some of the limitations of the study. The first limitation was that only the intermediate students were taught by the model of teaching geometry, while the primary students served as the control group. The second limitation was that the study was conducted in a single region of Greece. However, as the study was of small scale and context specific, the results may not be generalized to other regions of Greece. The third limitation was that the students were taught by the model of teaching geometry, while the control group was taught using the traditional teaching method. The fourth limitation was that the study was conducted in a single region of Greece. However, as the study was of small scale and context specific, the results may not be generalized to other regions of Greece.

The need for constructivist and exploratory approaches in teaching Informatics in Primary School has become even more relevant with the introduction of Programming, as part of the National Curriculum. Programming and Computer Science are becoming increasingly important in the modern world, and the integration of these subjects into the curriculum is essential. The study of programming and computer science is increasingly important in the modern world, and the integration of these subjects into the curriculum is essential. The study of programming and computer science is increasingly important in the modern world, and the integration of these subjects into the curriculum is essential.

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2007 it is structured through the teaching of the designed module "Programming". In this module, students learn informatics and software development skills in a project-oriented way. The module is designed to facilitate the teaching of the students' learning environment or to enhance computer programming skills and the ability to use computer-implemented software tools. The module follows a project-oriented approach, which includes students in the design, implementation, and testing of software solutions. The module is structured to facilitate the integration of various educational and research domains, and to enhance the students' learning experience. The design of the module is based on the following principles:

1. The module is organized around a series of projects, each of which is designed to achieve specific learning outcomes.
2. The projects are designed to be self-directed, allowing students to take an active role in their learning.
3. The projects are designed to be collaborative, allowing students to work together to achieve their learning goals.
4. The projects are designed to be assessed, allowing students to receive feedback on their performance.

The module is designed to enhance students' learning outcomes in the following ways:

1. The module is designed to facilitate the development of critical thinking and problem-solving skills.
2. The module is designed to facilitate the development of creativity and innovation.
3. The module is designed to facilitate the development of interpersonal skills.
4. The module is designed to facilitate the development of teamwork and collaboration.

In summary, the module is designed to facilitate the development of a range of educational and research domains, and to enhance the students' learning experience.
Programming scenario and interpret it into lines of code. Moreover, students learn to work in The hindering of these difficulties is important, as successful teaching and learning of computer programming can be extremely beneficial for twenty-first century diffi culties are still present and students seem to be even less interested in programming (Lahtinen, Ala-Mutka, & Jarvinen, 2005 ).

In education and daily practice, computers are often seen as a tool to support teaching (Bonar & Soloway, 1985). In this study, we have investigated the impact of the use of computer-aided learning on the learning process of primary school students and teachers. The main goal of this project was to improve the understanding of the computer's language. The results of our study show that the use of computers has a positive impact on the learning process of primary school students. The use of computers also helps to improve the understanding of the computer's language. The results of our study show that the use of computers has a positive impact on the learning process of primary school students. The use of computers also helps to improve the understanding of the computer's language.

In conclusion, the results of our study show that the use of computers has a positive impact on the learning process of primary school students. The use of computers also helps to improve the understanding of the computer's language. The results of our study show that the use of computers has a positive impact on the learning process of primary school students. The use of computers also helps to improve the understanding of the computer's language. The results of our study show that the use of computers has a positive impact on the learning process of primary school students. The use of computers also helps to improve the understanding of the computer's language.

Table 1: Comparison of the two groups in primary school

<table>
<thead>
<tr>
<th>Group</th>
<th>CG</th>
<th>EG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Teachers</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Learning time</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Learning tasks</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

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Table 2: Comparison of the two groups in primary school

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the basic concepts of how the written code is deployed, while Cera explains exactly what the code is.

- **Two avatars named Ele and Cera help students during the game in various ways:**
  - **Wu's Castle:** loops, arrays, C++ Arrays management, movement.
  - **Scratch, Compalgo:** structured computer programming.
  - **Prog&Play:** three-dimensional scaffolding.
  - **C# Depth-first search algorithm:** Two-dimensional scaffolding.
  - **EleMental: The Recurrence:** it teaches students how to execute recursion and depth-first search transversal using the C# programming language. The player has to navigate across a virtual binary tree by using simple and nested loops with the usage of a micro-language (Barnes et al., 2007).
  - **Saving Princess Sera:** it is a two-dimensional game that enables students' scaffolding through explanatory messages directed to the player. Each player has to try and progress through the game's levels; otherwise they are given corresponding feedback.

**Table 1**: Overview of the educational games for computer programming courses

<table>
<thead>
<tr>
<th>Educational Games for Computer Programming Education</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational Games Focused on Teaching</strong></td>
</tr>
<tr>
<td>- Educational games that are designed to help students understand the fundamental concepts of computer programming, such as loops, arrays, and recursive algorithms. These games are designed to be engaging and interactive, allowing students to learn through play.</td>
</tr>
<tr>
<td>- Games that use a micro-language to help students construct and execute simple and complex programs. These games are designed to help students develop their coding skills and understand the underlying principles of programming.</td>
</tr>
<tr>
<td><strong>Educational Games for Teaching</strong></td>
</tr>
<tr>
<td>- Educational games that are designed to help teachers deliver effective instruction in computer programming. These games can be used to supplement traditional teaching methods or as a standalone resource.</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

This section presents a series of games that have been developed specifically for educational purposes in computer programming courses. The games are designed to be engaging and interactive, allowing students to learn through play and practice. They are also designed to help teachers deliver effective instruction in computer programming. The games are based on educational research and best practices in computer programming education, and they are designed to help students develop the skills and knowledge they need to succeed in their future careers in computer science.

**Educational Games for Computer Programming Education**

- **EleMental: The Recurrence:** it teaches students how to execute recursion and depth-first search transversal using the C# programming language. The player has to navigate across a virtual binary tree by using simple and nested loops with the usage of a micro-language (Barnes et al., 2007).
- **Saving Princess Sera:** it is a two-dimensional game that enables students' scaffolding through explanatory messages directed to the player. Each player has to try and progress through the game's levels; otherwise they are given corresponding feedback.

**Educational Games for Teaching**

- Educational games that are designed to help students understand the fundamental concepts of computer programming, such as loops, arrays, and recursive algorithms. These games are designed to be engaging and interactive, allowing students to learn through play.
- Games that use a micro-language to help students construct and execute simple and complex programs. These games are designed to help students develop their coding skills and understand the underlying principles of programming.

**Educational Games for Teaching Computer Programming**

- Educational games that are designed to help teachers deliver effective instruction in computer programming. These games can be used to supplement traditional teaching methods or as a standalone resource.
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- Educational games that are designed to help teachers deliver effective instruction in computer programming. These games can be used to supplement traditional teaching methods or as a standalone resource.
- Games that use a micro-language to help students construct and execute simple and complex programs. These games are designed to help students develop their coding skills and understand the underlying principles of programming.
We examined the educational games in terms of the educational value that they bring, and we derived that they can provide students with:

- Interesting scenarios with comprehensive problems they have to solve, which increase motivation and the development of skills when learning programming.
- Clear educational goals and learning outputs, ensuring that they know what they have to do to achieve the required knowledge and skills.
- A constructive environment that promotes the involvement of students and their cooperation in the group.
- Immediate feedback that provides constructive comments through text, graphs, and tables, which enhance the learning process and improve the development of programming skills.
- The ability to learn at their own pace, with guidance and support when needed, which facilitates the development of programming skills.
- The opportunity to interact with peers, which increases motivation and the development of social skills.
- The opportunity to practice programming concepts repeatedly, which increases the development of programming skills.

Conclusion

In conclusion, the design and implementation of educational games for teaching computer programming should be based on the following guidelines:

- The games should be designed to support the learning process through the use of multimedia elements, such as images, sounds, and animations.
- The games should be designed to support the learning process through the use of immersive elements, such as virtual worlds and avatars.
- The games should be designed to support the learning process through the use of interactive elements, such as drag-and-drop interfaces and code editors.
- The games should be designed to support the learning process through the use of feedback mechanisms, such as error correction and performance analysis.
- The games should be designed to support the learning process through the use of evaluation mechanisms, such as self-assessment and peer assessment.
- The games should be designed to support the learning process through the use of collaborative elements, such as team-based learning and peer tutoring.
- The games should be designed to support the learning process through the use of adaptive elements, such as intelligent tutors and personalized learning paths.

References

Hermeneutic Unit: Systematic literature review relating to the use if IC...

Highfield and Mulligan (2008) describe various instances where early childhood activities, enough for activating children's inner motives, the formation and the organisation of language paradigm. These toys have a Logo-like robust interface and are technological devices using this specific language.

Beraza, Pina, and Demo (2010) in their study presented teacher-orientated robotics activities in order to support teachers in their practice. They claim that the programmable toy Bee-Bot is suitable for early childhood and primary education but not for younger children such as the Bee-Bot may cover other cognitive areas as well as a variety of cognitive and social skills is reinforced (Bers & Horn, 2010; Yelland, 2007).

The Logo programming language developed in the mid-1960s at the M.I.T. Artificial Intelligence Laboratory is introduced in a number of early childhood educational materials and environments which are based on the technology of the LEGO ® Foundation. The added value of this specific programming language is the fact that it is appropriate for early childhood development and support abilities such as problem-solving, inquiry and experimentation (Rogers & Portsmore, 2010).

The second category includes the robotic programmable toys such as the Roamer, which is a programmable toy designed and produced by the LEGO § A/S. It is a small, friendly (robust) interface and a more playful appearance. It is the centre of the scientific interest for this specific robotic environment which is based on the technology of the LEGO ® Foundation. The added value of this specific programming language is the fact that it is appropriate for early childhood development and support abilities such as problem-solving, inquiry and experimentation (Rogers & Portsmore, 2010).

The Logo programming language implementation have been used for educational purposes. Since then a series of robots featuring a common Logo-like programming language have been developed and used for educational purposes. The first robot is the Turtle (1985) Logo Programmable toy, MB N/A Maths.

Further research activity. Since then a series of robots featuring a common Logo-like programming language have been developed and used for educational purposes. The first robot is the Turtle (1985) Logo Programmable toy, MB N/A Maths.

Recently the term “Educational Robotics” refers to the teaching practice during which the students use the robots to construct knowledge with the help of or for the robots. The term “Robotic Education” is defined by the use of Information and Communication Technologies (ICT) to support learning, teaching and development of new educational processes. The main aim of educational robotics is the development of new educational methodologies, the creation of new learning opportunities and the introduction of new teaching strategies.

The framework of the integration of robotics in education allows us to design innovative learning environments, to develop interactive and engaging learning materials, to promote students' learning within the educational context. The term “Robotic Education” is defined by the use of Information and Communication Technologies (ICT) to support learning, teaching and development of new educational processes. The main aim of educational robotics is the development of new educational methodologies, the creation of new learning opportunities and the introduction of new teaching strategies.
Furthermore, Csink and Farkas (2010) gave emphasis to the use of floor-robot approach. The development of a pseudo-language, through a series of graphical representations and their manipulation of the Bee-Bot is recorded. However, there is still lack of systematic observation and recording of children’s learning processes with the Bee-Bot (Pekarova, 2008). In other cases an attempt to trace children’s initial intentions of using the Bee-Bot (Pekarova, 2008). On the contrary it is Pekarova (2008) who claims that the programmable toy user is supported and reinforced to find the appropriate commands/cards of orientation and direction, visualizing the program, matching each command/card to a user. The importance of designing an educational scenario is to include issues of didactic transposition, educational context, and well-organized learning environments. The proposed educational framework includes seven (7) distinct phases (Fig. 1) for designing an educational scenario. The importance of designing an educational scenario is to include issues of teaching programming as well as for problem-solving situations. Especially the more emphasis on the development of abilities concerning mathematical concepts, educational planning and educational contexts. In our case, the integration of teaching programming and educational contexts created a more explicit context not only for the children but also for the teachers. For children it is self-evident to deliver the epistemological knowledge under appropriate transposition, while for the teachers it was necessary to develop the didactic transposition of the teaching programming according to the curriculum expectations. In this way, the children can have the opportunity to discover the feature desired outcome came through the experimentation with the programmable toy as the best way for children to develop programming skills. The experimentation gave children the opportunity to discover the feature of the Bee-Bot’s animated and playful appearance, enabling children to inquire, explore and experiment. The experimentation also helped children to develop the epistemological knowledge under appropriate transposition, while for the teachers it was necessary to develop the didactic transposition of the teaching programming according to the curriculum expectations. In this way, the children can have the opportunity to discover the feature of the Bee-Bot’s animated and playful appearance, enabling children to inquire, explore and experiment. The experimentation also helped children to develop the epistemological knowledge under appropriate transposition, while for the teachers it was necessary to develop the didactic transposition of the teaching programming according to the curriculum expectations. In this way, the children can have the opportunity to discover the feature of the Bee-Bot’s animated and playful appearance, enabling children to inquire, explore and experiment. The experimentation also helped children to develop the epistemological knowledge under appropriate transposition, while for the teachers it was necessary to develop the didactic transposition of the teaching programming according to the curriculum expectations. In this way, the children can have the opportunity to discover the feature of the Bee-Bot’s animated and playful appearance, enabling children to inquire, explore and experiment. The experimentation also helped children to develop the epistemological knowledge under appropriate transposition, while for the teachers it was necessary to develop the didactic transposition of the teaching programming according to the curriculum expectations. In this way, the children can have the opportunity to discover the feature of the Bee-Bot’s animated and playful appearance, enabling children to inquire, explore and experiment. The experimentation also helped children to develop the epistemological knowledge under appropriate transposition, while for the teachers it was necessary to develop the didactic transposition of the teaching programming according to the curriculum expectations.
Dans Sciences et technologies de l'information et de la communication (STIC) en milieu éducatif: Objets et méthodes d'enseignement et d'apprentissage, de la maternelle à l'université.

par les petits enfants à l'aide de jouets programmables enfants à l'aide de jouets programmables


into account. This approach is implied by the broader context of educational robotics thus is the constructionism (Papert, 1980 ) and the social-constructivism.

Last but not least, an appropriate adaptation for implementation by in-service teachers in typical classrooms, taking the role of facilitators and co-researchers was take.

Adopted and adapted approaches are not characterized, steps were based on small- and large-group interview.

The data gathered through small and large group interviews and teachers’ observations that have been gathered during the implementation process. This data was used to refine the in-service training program.


activities of a cognitive style such as inquiry, experimentation, observation, and

DePover, C., Karsenti, T., & Komis, V. (2007). Enseigner avec les technologies: Favoriser les

environment/language for teaching robotics using Lego Mindstorms? Artificial Life Robotics,


conceptual frameworks. Subjects were asked to construct an initial algorithm for the programmable toy. In the next section, children were presented to the programmable toy as a system and they were asked to state algorithms which were connected with the programmable toy system. The children were also asked to verbalise the kind of thinking that was involved in the construction of algorithms. Moreover, they were asked whether or not they had similar experiences in the past.

The application of the educational scenarios in typical classrooms in early childhood education, showed that preliminary concepts of programming could be developed through the use of programmable toys. Thus the cognitive potential (Depover

The design of the scenario included introducing children to concepts of algorithm and the programmable toy is an educational context where children can be encouraged for the development of strategies and algorithms for solving problems.

The results indicated that the use of educational scenario was more effective for improving the children's cognitive abilities and problem-solving situations.

Greff, E. (2001). Résolution de problèmes en grande section autour des pivotements à l'aide du


children if a systematic, structured, principled and theory-based framework is used.

Discussion

and De Michele et al. ( 2008 ).

The application of the educational scenarios in typical classrooms in early childhood education, showed that preliminary concepts of programming could be developed through the use of programmable toys. Thus the cognitive potential (Depover


Blog is considered an important tool of the Web 2.0 toolbox (Richardson, 2009) and blogging has become one of the most popular Web 2.0 activities. The origins of the blog can be traced back to the late 1990s, but it was not until the early 2000s that blogs started to gain widespread popularity. Blogs are a type of website that are written by individuals or groups and are organized in reverse chronological order, with the most recent post appearing first. They are often used to share personal thoughts, opinions, and ideas, as well as news and information on a wide variety of topics. Blogging has become a popular way for people to express themselves, connect with others, and share their ideas and experiences. 

Blogs can be used in a variety of ways, from personal journals to professional platforms. Many people use blogs to document their daily experiences, share their thoughts on current events, or discuss topics of personal interest. At the same time, many organizations use blogs to communicate with their stakeholders, share news and updates, and engage in two-way conversations with their audience. 

Educational blogs are particularly useful for promoting critical thinking and collaboration among students. They provide a platform for students to express their thoughts and ideas in writing, and for them to read and respond to the writing of others. This can help to foster a sense of community and engagement within the classroom, as students work together to develop their understanding of the topic at hand. 

In addition to promoting learning and collaboration, educational blogs can also be used as a form of assessment. By reviewing and providing feedback on student blog entries, teachers can gain insight into their students' understanding of the material, as well as their writing and critical thinking skills. 

However, it is important to note that the use of blogs in education should not be seen as a panacea for all educational challenges. While blogs can be a useful tool for promoting learning and collaboration, they should be used in conjunction with other instructional strategies, such as traditional lectures and discussions. Moreover, it is important to ensure that the use of blogs is done in a way that is consistent with the educational goals of the course and the learning outcomes that are intended to be achieved.
relatively lower scores than the teaching presence. The data supports that it was an important role within the teaching and learning process. The educator facilitated questions (all students' responses). The iterative coding process employed leaded to as well as through blog's activities seemed to have strengthened the sense of collaboration. The educator managed to develop a community where the educator and students' interaction was enhanced as well as through blog's activities. The educator wanted to grant students the freedom and flexibility needed to express themselves. The data collection process was conducted during October–November 2011. Regarding the gender of the students, 55% was boys and 45% was girls, while the majority of the students (85%) use the computer, of which 25% use it once per week and 5% use it daily (mean = 2.8; SD = 1.11). The majority of the students' opinions, views, thinking would be revealed at the blog wall. The teaching presence involves the design, facilitation, and direction of cognitive learning. The theoretical framework of the current study focuses on the Community of Inquiry (CoI) as a fundamental concept. The CoI requires intersubjective agreement among the participants on the nature of the inquiry and the process of knowledge construction. The introductory concept described the nature of knowledge, formation, and the process of scientific inquiry. An educational community of practice is a complex learning environment where the learners are engaged in collaborative and reflective activities. The CoI is a framework that integrates various theories and perspectives, such as constructivism, sociocultural theory, and activity theory. The CoI is divided into three phases: social presence, teaching presence, and cognitive presence. The social presence relates to the establishment of a supportive environment such that meaningful interactions and collaborative learning can take place. The teaching presence involves the design, facilitation, and direction of cognitive learning. The cognitive presence is involved with the mental activity of the learners, such as the ability to engage in reflective thinking and critical analysis. By the completion of the Language and Linguistics course the students were familiar with all the concepts of the course. The educator gave various interesting activities, motivated students' interest, and online postings enabled students to understand the basic concepts of the course. The educator gave various interesting activities, motivated students' interest, and online postings enabled students to understand the basic concepts of the course. The educator gave various interesting activities, motivated students' interest, and online postings enabled students to understand the basic concepts of the course. 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The educator gave various interesting activities, motiva...
classmates, deadlines, combination of blog and classroom activities; and provide dialogue, discussion, interaction and interactivity, coexistence, and collaboration within the primary education is highly evident given the results of the current study. The possibility of incorporating the blog as an educational tool to a greater extent

### Conclusion

To effectively design blended learning environments; sufficient time for students to use the blog should be in place. First of all, the educator should have a greater presence and involvement within blog activity. The educator needs to directly lead and guide the blog performance of blogging. British Journal of Educational Technology, 41 (3), E39–E43.

Students

Teachers

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Various skills, such as writing, IT, collaboration, and organizational skills (Lai & Roberts, 2007), foster contribution to peers (West & West, 2009), and improve students' engagement (Molyneaux & Brumley, 2007).

Unsurprisingly, wikis have been used in various contexts such as developing an online textbook (Ravid, Kalman, & Rafaeli, 2009), a single-group pretest–posttest design was adopted (Cohen, Manion, & Morrison, 2007), and a single-group pretest–posttest design was adopted (Cohen, Manion, & Morrison, 2007). This study investigates:

- Whether students with more logged wiki edits benefited more than students with less logged wiki edits.
- Whether students who spent a greater amount of time editing contributed more to the wiki than students who spent less time editing.
- Whether students' learning gain was higher for students who spent a greater amount of time editing than for students who spent less time editing.

The wikispaces service (www.wikispaces.com) was used both for the activity and the assessment. The study was framed, rigorously designed, wiki-based activity on the learning outcome. In specific, this chapter investigates:

- Whether students with more logged wiki edits benefited more than students with less logged wiki edits.
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The methodology was chosen to evaluate the impact of Web 2.0 and its applications in the frame of a first-year academic course entitled “Introduction to Web 2.0 and its applications.” It was selected due to the following reasons: First, the students should be able to understand the impact of Web 2.0 on society in general and through an exemplary wiki, which was constructed by the researchers (available at http://www.wikispaces.com/ExemplaryWiki).

The approach used for the research was based on an instruction on the wiki's basic functionality and a compulsory assignment. Subsequently, a compulsory assignment was presented to them in the form of a questionnaire, available at http://www.surveymonkey.com/s/3456789. The assignment was presented to the students and it was composed of three sections:

- Knowledge: the students were required to answer factual questions (36 questions, each with four possible answers of which only one was correct).
- Application: the factual knowledge questions were primarily related to general knowledge questions (36 questions, each with four possible answers of which only one was correct). The factual knowledge questions were primarily related to general knowledge questions (36 questions, each with four possible answers of which only one was correct). The factual knowledge questions were primarily related to general knowledge questions (36 questions, each with four possible answers of which only one was correct).
- Reflection: the students were required to answer reflective questions based on the students' individual learning experience.

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- Whether students' learning gain was higher for students who spent a greater amount of time editing than for students who spent less time editing.
Although the quality of a course does not depend only on its content but also on its structure, organisation, support, delivery, etc., content plays a crucial role for the success of e-learning. In order to ensure this fact, it is necessary...
and Ventura (2010) “the term DM is used in a larger sense than the original/traditional DM definition”. Although there is a great deal of research in the field of DM

Data mining (DM) in education uses computational approaches to analyse educational data in order to analyse upcoming educational issues. According to Romero

per quarter, top search terms and number of downloads of e-learning resources were

the consequent Y in all transactions in the database. The Weka system has several

mark according to their performance on the course. Having measured the students’

Courseware Evaluation Through Content, Usage and Marking Assessment156

us for predicting the time to be spent on a learning page (Arnold, Scheines,

Wasson (1999) use a multivariable regression model to predict a learner’s performance from log and test scores in Web-based instruction. Multiple linear regression

algorithm) (Cetintas, Si, Xin, & Hord, 2009). Yu, Jannasch-Pennell, Digangi, and

(2005) and to predict the probability a student has

on association rule mining. Association rule mining is one of the most well studied

activity in the e-learning system according to the measures and metrics, it is possible to investigate whether there is a relationship between student activity in the

I. Kazanidis et al.151

metrics and the mean marks from the corresponding courses are investigated for

applied to the e-learning data. More specifically, the values of the measures and

A view of the collected data is shown in Table 4. The values of the measures of

(3)

The VPD expresses the number of visits per duration. A high number of VPD

is used for predicting the time to be spent on a learning page (Arnold, Scheines,

is used for predicting the time to be spent on a learning page (Arnold, Scheines,

TOP-

A view of the proposed schema of the approach is depicted in Fig. 1.

be applied to the e-learning data. More specifically, the values of the measures and

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The courses were classified into three classes according to their mean marks. (1) It shows that the measure Pages is better classified based on the OneR algorithm. The third class which corresponds to courses with high marks is described by the equation:

\[\text{Pages} \geq 7.66667\]

The results of this research are remarkable from a pedagogical point of view. On the one hand, the results show the existence of two clusters which correspond to high marks. However, the values of the two clusters there is a high degree of similarity. Therefore, the measure Pages is better classified based on the OneR algorithm. The third class which corresponds to courses with high marks is described by the equation:

\[\text{Pages} \geq 7.66667\]

Table 4: Tracked data, measures, metrics and marks

<table>
<thead>
<tr>
<th>Course</th>
<th>Pages</th>
<th>Visits</th>
<th>Sessions</th>
<th>Duration</th>
<th>Interest</th>
<th>Motivation</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD3106</td>
<td>2,533</td>
<td>5,115</td>
<td>108</td>
<td>3.59</td>
<td>0.495</td>
<td>0.106</td>
<td>5.98</td>
</tr>
<tr>
<td>AD6100</td>
<td>5,271</td>
<td>29,290</td>
<td>29,290</td>
<td>1.95</td>
<td>0.643</td>
<td>0.053</td>
<td>6.67</td>
</tr>
<tr>
<td>AD2107</td>
<td>13,824</td>
<td>2,206</td>
<td>2,206</td>
<td>2.71</td>
<td>0.732</td>
<td>0.0248</td>
<td>7.19</td>
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<td>AD6107</td>
<td>3,538</td>
<td>11,525</td>
<td>11,525</td>
<td>2.15</td>
<td>0.590</td>
<td>0.106</td>
<td>6.53</td>
</tr>
<tr>
<td>AD7100</td>
<td>2,724</td>
<td>0</td>
<td>0</td>
<td>4.04</td>
<td>0.616</td>
<td>0.2488</td>
<td>6.28</td>
</tr>
<tr>
<td>AD3102</td>
<td>1,515</td>
<td>0</td>
<td>0</td>
<td>1.27</td>
<td>0.410</td>
<td>0.3556</td>
<td>4.45</td>
</tr>
<tr>
<td>AD6111</td>
<td>2,719</td>
<td>1,355</td>
<td>1,355</td>
<td>3.53</td>
<td>0.497</td>
<td>0.071</td>
<td>6.34</td>
</tr>
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<td>AD5101</td>
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<td>0</td>
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<td>0.431</td>
<td>0.444</td>
<td>6.11</td>
</tr>
<tr>
<td>AD4101</td>
<td>3,284</td>
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<td>250</td>
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<td>0.457</td>
<td>0.1955</td>
<td>5.65</td>
</tr>
<tr>
<td>AD6105</td>
<td>3,586</td>
<td>7,198</td>
<td>7,198</td>
<td>2.57</td>
<td>0.653</td>
<td>0.1244</td>
<td>5.88</td>
</tr>
<tr>
<td>AD5104</td>
<td>2,891</td>
<td>785</td>
<td>785</td>
<td>3.26</td>
<td>0.542</td>
<td>0.213</td>
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</tr>
<tr>
<td>AD4108</td>
<td>3,185</td>
<td>100</td>
<td>100</td>
<td>4.30</td>
<td>0.511</td>
<td>0.1777</td>
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</tr>
<tr>
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<td>27</td>
<td>27</td>
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</tr>
<tr>
<td>AD6107</td>
<td>2,088</td>
<td>11,525</td>
<td>11,525</td>
<td>2.15</td>
<td>0.590</td>
<td>0.106</td>
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</tr>
<tr>
<td>AD7100</td>
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<td>0</td>
<td>4.04</td>
<td>0.616</td>
<td>0.2488</td>
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</tr>
<tr>
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</tr>
<tr>
<td>AD5101</td>
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<td>1.80</td>
<td>0.431</td>
<td>0.444</td>
<td>6.11</td>
</tr>
</tbody>
</table>

These results show that the measure Pages is better classified based on the OneR algorithm. The third class which corresponds to courses with high marks is described by the equation:

\[\text{Pages} \geq 7.66667\]
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

95 of 519

Kazanidis, I., Theodosiou, T., Petasakis, I., & Valsamidis, S. (2013). Online courses assessment
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Introduction
This chapter builds on previous work about the use of technologies for learning in
cultural institutions (Yiannoutsou, Bounia, Roussou, & Avouris, 2011 ) where an
analysis of selected cases revealed that technology mainly functioned as a medium
for information delivery. This use of technology treats culture as something that can
be “transferred” from the “knowledge holding” museum to the visitor. In this context museum experience is structured around the consumption metaphor: the
museum produces “information” in digital or other form, for the visitor to consume.
Studies evaluating this type of cultural experience used the term “museum fatigue”
to highlight visitor limited ability to remember, digest and utilise the information
offered (Bitgood, 2009 ). Another line of research, reports decrease in the audience
of museums and cultural institutions (Simon, 2010 ). Taking into account the above
observations we could argue that technology has been employed in various ways by
museums to support their reconnection with the public where we identify two main
trends with respect to the learning experience pursued. The fi rst focuses on refi ning
the information and the way it is delivered to the visitor. The second redefi nes the
role of the visitor and his/her relationship with the museum in the process of culture
creation. In this paper we will briefl y refer to technologies supporting the information delivery metaphor and we will further expand on how technologies can support
a learning experience based on visitor participation in the process of culture
creation.
Game Design as a context for Learning in
Cultural Institutions
Nikoleta Yiannoutsou and Nikolaos Avouris
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University campus , Rio 26504 , Greece
e-mail: nyiannoutsou@upatras.gr; avouris@upatras.gr166
Personalization and Games: Same Content
in New Clothing?
In this section we will discuss the learning implications of two examples which
we consider that involve information transfer: personalization and technologysupported games. These two examples represent the current trend in technology
development to support and enhance museum experience (see for example the
funded EC projects in FP7 and the recent call for digital culture, Cordis, 2012 )
applied in order to attract more visitors to the museums. Here we will only discuss
the rationale underlying in general the learning experience that seems to be supported by these two examples.
Personalization aims at adjusting and transforming cultural experience so as to
meet the experiences, interests and knowledge at the level of the individual visitor
or the group. To this end, technology suggests the most appropriate content to the
user based (i) on visitor profi les, (ii) on the cumulative visitors’ history (Bohnert,
Zukerman, Berkovsky, Baldwin, & Sonenberg, 2008 ; de Gemmis, Lops, Semeraro,
& Basile, 2008 ) (iii) on user-generated content (e.g. tags and comments) and on
combinations of these methods. The rationale for applying such techniques is that
cultural heritage sites have a huge amount of information to present, which must be
fi ltered and personalised in order to enable the individual user to easily access it.
Although this approach supports visits adjusted to visitor interests and previous
experience, it is underlined by the concept of visitor as consumer of information;
more fi ne grained this time. Thus, personalised interaction eager to bring visitors
closer to the museum employs tools and methodologies to accommodate the visitors’ interests but at the same time reproduces the initial distance between the visitor
and the authority of the museum who owns culture and now also knows what is best
for each visitor.
The infusion of new technologies in cultural institutions and more specifi cally,
of mobile technologies have resulted in new ways of experiencing games in cultural institutions (spatial awareness) and have helped in reaching a larger audience
(not only children but also adult visitors). We focus on mobile games because they
support the cultural experience during the visit of the cultural institutions as
opposed to games appearing for example in museum web sites aiming to prepare
for the visit or enhance the experience after the visit. Many mobile games however,
created for supporting cultural experience with the aim to engage users fail to bring
at the centre of the activity the cultural content in playful ways. So there are game
and story instances (see for example Akkerman, Admiraal, & Huizenga, 2009 ;
Paay et al., 2008 ) where players seem to be enjoying the cultural experience but the
question remains as to how cultural content is integrated in these games/stories and
what game characteristics invoke visitor engagement. Our observation is that quite
often visitors engage with cultural content (e.g. explore the historical centre of a
city) in the context of following the plot of a mystery story or being engaged in a
role playing game. Yet in many cases engagement with cultural content remains at
a superfi cial level as it is not smoothly integrated in the story or the game
N. Yiannoutsou and N. Avouris167
(Yiannoutsou & Avouris, 2012 ). As a result, engagement with the cultural content
(e.g. responding to questions, taking pictures) becomes the “price the visitors have
to pay” in order for the interesting things and the fun to carry on (e.g. to see what
happens next in the mystery story, or who is the murderer, or to continue playing
the game). Furthermore, the output of this process is factual information (e.g. visitors end up knowing that there is a convent in the city) leaving outside other aspects
of the cultural experience (creativity, fi nding connections with own experience,
gaining ownership over the cultural experience, etc.).
To sum up, in this section we focused on the learning involved when using personalization techniques and games to support cultural experiences. We discussed
these two examples due to their wide adoption in cultural institutions during the last
years and because they are claimed to result in active visitor engagement with cultural content. Our analysis showed that the mainstream use of these approaches ends
up often in consuming or collecting factual information by the visitor where the
museum is the entity that holds the knowledge for the visitor to collect it or consume
it. This is not to imply that game and personalization technologies can only support
the information consumption metaphor. Instead, as we will show in the next section,
personalised learning and games can offer rich learning opportunities if they are
integrated in a different rationale with respect to the role of the visitor, his/her relationship with the museum and the goal/nature of learning in cultural institutions.
Participation as a Context for Rethinking Technologies
that Support Learning in Museums
Participation-based cultural experience is based on the assumption that culture is
generated dynamically through the dialectic relationship between the museum and
the visitor (Simon, 2010 ). Proctor ( 2009 ) used the metaphor “From Parthenon to
Agora” to illustrate the shift from the perception of cultural experience as something that the museum holds and the visitors see but don’t touch, to something that
can be discussed, shared and negotiated. Apparently, the role of the visitor in this
context changes to collaborator and partner (Simon, 2010 ). Furthermore participatory cultural experiences imply a new relationship between the visitor and the
museum which is not restricted to one off or fi rst time visits. Instead, participation
aims also at building an enduring relationship with existing audiences and communities (museum friends, volunteers, etc.) related to the museum (Black, 2005 ).
Building an enduring relationship between the visitor and the museum through visitor active participation enhances the cultural experience and enriches the content
and the impact of the museum on fi rst time visitors or one off visitors too (ibid).
In the wide spectrum of participatory activities (for a detailed presentation see
Simon, 2010 ) we identifi ed two types of activities relevant to our analysis. The fi rst
type of activity reserves for the visitor a role similar to the documentation process
performed by the museum. The proliferation of mobile technologies and social
Game Design as a context for Learning in Cultural Institutions168
media has supported the creation of user generated content using various crowdsourcing practices. Ridge ( 2011 ) has offered a grouping of these practices:
• Stating preferences , voting on interesting objects, comments, etc.
• Tagging : unstructured text associated with objects, see for example the Steve
project http://tagger.steve.museum/ which addresses social tagging as a process
that encourages visitor engagement and provides new ways of describing and
accessing culture . Twenty-one Institutions participate in the project with 97,041
Objects. In the site appears that 8,346 users have produced 552,105 terms for the
above objects.
• Debunking, criticising : arguing against other peoples’ ideas, tags, etc. (see for
example the Freeze Tag project in Brooklyn museum http://www.brooklynmuseum.
org/opencollection/freeze_tag/start.php ).
• Recording personal stories : personal memories associated to museum objects or
memorabilia made available to digital collections. See for example Europeana
• Linking objects or categorising : grouping of objects or associating them with
themes.
The second type of activity aims at resuming or approaching cultural experience
through engaging visitors in the creations of “meta-artefacts”—i.e. games or stories
based on compositions of elements of cultural content—which are supposed to have
a public status. The idea of involving visitors in creating computer-based public
artefacts that make use of cultural content is new. It builds on a theoretical background that acknowledges the gap in the communication between the museum and
the visitor and calls for active participation of visitors in the dialogue with the museums (Hein, 2006 ; Simon, 2010 ).
Three examples are known and presented here: One comes from British Museum
which included in the museum activities family workshops on game design.
Participants were invited to build their own games inspired by the collections of the
British Museum (after visit experience). The new games could be uploaded on the
Web to be played at home or shared with friends. The second example comes from
Tate Gallery where young visitors (6–12 years) create drawings through game play
(Jackson, 2011 ) and fi lms for pieces of art. The third example is the idea of remixing
museum content for the creation of a visitor generated narrative (Fisher & TwissGarrity, 2007 ). This example is grounded on the observation that visitor centric exhibition narratives should not be the objective of the cultural experience, but instead
the focus should be cultural activities promoting the construction of narratives by the
visitors. Visitor generated narratives build on the transformative connection between
the visitor and the exhibit, asserted by Hein ( 2006 ). Transformative experiences can
occur when the visitor is encountered with challenges to discover connections with
the exhibits and is provided with the tools to analyse and manipulate the exhibits in
order to transform them into something new, related to his/her experience.
Although both activity types (“crowdsourcing” and “meta-artefacts”) reserve an
active role for the visitors they have a drawback: visitor generated “products”—content
or artefacts—are almost never integrated in the museum’s assets because of their low
N. Yiannoutsou and N. Avouris169
quality (Simon, 2010 ). This problem is related to the open ended and unstructured
participatory activities:
When it comes to participatory activities, many educators feel that they should deliberately
remove scaffolding to allow participants to fully control their creative experience. This creates an open-ended environment that can feel daunting to would-be participants. … What if
I walked up to you on the street and asked you to make a video about your ideas of justice
in the next three minutes? Does that sound like a fun and rewarding casual activity to you?
(ibid, Chap. 1, p. 13)
What Simon described above draws upon an approach which asserts that learning in museums should focus in triggering visitor creativity and subjective interpretation of cultural content leaving aside the “knowledge of the museum” which
prevails in the information consumption metaphor. Simon showed that in participatory activities this perspective has its weaknesses. In the same line comes the idea
of “objectifi ed cultural capital” (Bourdieu, 1986 ) which explains that cultural experience is not just an issue of access (i.e. being able to visit a museum) but it is also
an issue of background knowledge that supports the person to appreciate and understand the value of a piece of art. Museums and cultural institutions offer in the
process of culture creation not only the objects-exhibits but also the background
knowledge necessary to value the exhibits. In our view the key in this process is how
background knowledge will become the means to an end (i.e. a tool for the visitor
to generate cultural experience) and not the end itself. This means that cultural
experience is not diminished into comprehending institutional knowledge instead,
the latter needs to come into the visitor’s attention as material to be negotiated, discussed, shared and used for the construction of something new. In this context we
argue that technology can play a crucial role in supporting the cultural learning
experience and we further illustrate this by focusing on the example of game design
and its potential in supporting learning in cultural institutions.
Game Design as Learning Activity in Cultural Institutions
Game play is not a new practice for museums. The introduction of digital technologies resulted in revisiting the idea of game play and storytelling in museums.
Technologies today play a key role in interaction, interpretation, learning, content
creation through crowd-sourcing, outreach, marketing, etc. (for a detailed presentation and overview see Beale, 2011 ). Whereas there is an extensive analysis on game
play, research in cultural heritage sites have not addressed yet the idea of game
design as an end user activity.
Interestingly, research in the fi eld of technology enhanced learning has already
highlighted the learning potential not only of game play but also of game design and
development (Kafai, 2006 ). Game design activities were identifi ed as having the
potential of helping learners to build a new relationship with knowledge, as learners
feel ownership over the knowledge and experience deep interaction with the learning
concepts to be integrated in the game with a functional role. As Kafai, Franke, Ching,
Game Design as a context for Learning in Cultural Institutions170
and Shih ( 1998 ) observed, learners negotiated with learning concepts in this context,
in order for the game to be playable.
Research in the fi eld of game design by non-technical end users—such as students—has focused on the learning activity which has been analysed from two perspectives. The fi rst one focuses on studying learning related to programming or
specifi c skills and concepts (see for example Hoyles, Noss, Adamson, & Lowe
2001 ) for a discussion on children’s causal reasoning and rule understanding during
game construction). The second and most recent perspective acknowledges game

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design as a learning goal in itself (Hayes & Games, 2008). In this trend, researchers consider game design as an educational tool and aim to develop game design curricula. The National Science Foundation, for example, funds the Virtual Ageing Project, in which college students lead computer game design workshops for seniors. The goal is to develop a game design curriculum targeted at students in their early 20s. The project involves developing a curricular framework that integrates game design into the curriculum, developing pedagogical strategies for teaching game design, and creating a set of materials that can be used in game design courses.

The game design curriculum is designed to help students develop a deeper understanding of the design process, learn to think critically, and develop problem-solving skills. It is intended to be a part of a broader educational strategy to improve the preparation of students for the workforce.

In conclusion, game design is an emerging field with the potential to make a significant impact on education. The use of games for learning is gaining recognition and is becoming more prevalent in schools and universities. As game design becomes more widespread, it is likely to continue to evolve and be refined.

References:


The above references provide an overview of the current state of game design and its impact on learning. Further research is needed to explore the potential of game design in education and to identify best practices for its implementation.

In summary, game design has the potential to make a significant contribution to education. As more research is conducted in this area, it is likely that we will see a greater integration of game design into the curriculum and a greater awareness of its benefits among educators and policymakers.
The aim of the study was neither to test the usability of each application nor to determine their users’ satisfaction, but to study the opportunities for learning that each of the applications offers to museum visitors and the extent to which these opportunities are utilised. Specific objectives were set:

• To study the opportunities for learning that each of the applications offers to museum visitors, focusing on the previous theories about learning, the connection with theories about digital technology and the relevant literature on museum learning.

• To investigate the extent to which these applications utilise the aforementioned theories.

• To take into account the decisive role played by the social dimension of the educational process in the formation of the visitor’s experience of museums. Therefore, the museum learning process is an integral part of the social agenda of museums.

• To study the applications’ character and the extent to which they support the development of visitors’ digital competencies, and to investigate whether the applications utilise the relevant theories on how museum objects alter when they take digital form (see also Zacharias, 1995; König, 2012). The study investigated the educational implications of the applications and evaluated whether they can support active thinking and acting and whether they provide experiences of learning and meaning making.

• To study whether and to what extent theoretical perspectives on museum learning, as these are reflected in previous research, have been taken into account in the design of applications.

• To evaluate the use of museological perspectives in the design of applications.

• To take into account the role played by the social dimension of the educational process in the formation of the visitor’s experience of museums.

• To evaluate the use of museological perspectives in the design of applications.

The theoretical framework presented above poses a series of issues regarding the usability of the applications and the extent to which the applications support the development of digital competencies, as well as opportunities to contribute content and exchange ideas and information with other visitors.

The results of the study were used to create a framework for improving the applications and the design of future applications. The framework is based on the following principles:

1. Museum objects, the knowledge and experiences that users bring with them, the social and cultural agenda, the educational and the interactive potential of museum applications.

2. The connection between the digital and the real world, for expanding the digital experience into the real world.

3. The role of the social dimension in the formation of the visitor’s experience of museums.

4. The educational implications of the applications and the extent to which they provide experiences of learning and meaning making.

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4. The educational implications of the applications and the extent to which they provide experiences of learning and meaning making.

5. The use of museological perspectives in the design of applications.
Each of these parameters corresponds to a museum learning concern discussed:

- **Social context**
- **Creativity-experimental learning**

**User involvement:**

- Significance of collections/objects (authenticity, materiality, aesthetic value,
  analysis form consisted of the following fields (Table 2):

<table>
<thead>
<tr>
<th>Applications: Title</th>
<th>Funding</th>
<th>Application form</th>
<th>Target group</th>
<th>Languages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational CD...</td>
<td>EU and national funds</td>
<td>DVD ROM</td>
<td>6–12 years</td>
<td>Greek, English,</td>
</tr>
<tr>
<td>Modern Greek Art</td>
<td>EU and national funds</td>
<td>CD-ROM</td>
<td>School children</td>
<td>Greek,</td>
</tr>
<tr>
<td>Russian Olive Oil</td>
<td>EU and national funds</td>
<td>DVD ROM</td>
<td>14–18 years</td>
<td>Greek, English,</td>
</tr>
</tbody>
</table>

**Presupposed knowledge/experience of the user**
In order to examine perceptions of materiality and aesthetics, we examined the limitations of digital space as the three previously mentioned qualities/values. In the same way, especially in the narrative.

When it comes to the values/qualities of objects, it is clear that those of authenticity, materiality and aesthetics can be used only to a limited extent in a digital environment. This is because digital applications in museums are often more "common" or interesting for qualities other than aesthetics and uniqueness, as with the frieze from the Athenian Acropolis. In the case objects are considered more "common" or interesting for qualities other than aesthetics and uniqueness, as with not-for-profit environmental groups when discussing coins bearing marine animal symbols).

Digital Applications in Museums: An Analysis from a Museum Education Perspective

In order to focus on aesthetics in particular, we also examined the representation of the museum exhibits as a starting point, provides users with the opportunity to "discover" as a result of the activity and not as a prerequisite for it. This is the case with the Numismatic applications of the Numismatic Museum. Digital applications of the Numismatic Museum also exist in Greek and English languages than Greek, such as in the application for the Costakis Collection, which is only in Greek (see Table 1).

In many applications, the user can view objects from different angles and on closer examination, users can select objects on the screen to examine and knowledge that users have had previous care of these objects. When we examine objects in a virtual environment, these objects usually have a limited number of options to choose from. For instance, users can choose between different actions to be performed on the object, such as viewing it from different angles and scales, selecting objects and looking at them in a virtual environment or by clicking on them to see more information. In many cases, the user can also choose to read additional information about the objects and the context in which they are used.

Almost half of the applications (14 out of 25) are offered just in the Greek language. In the case of digital discs (CD-ROMs) there is usually a choice of other languages than Greek, such as in the application for the Costakis Collection, which is only in Greek (see Table 1). The number is growing as well as the interest of museums to acquire a presence in web applications, and the rest is only in Greek (see Table 1).

An exception to this can be found at the Natural History Museum at Axioupolis, which offers a "screen" with an active "fairytale-like" image and numerous activities on the screen, including "Games" and "Tools" sections, and "Activities" for children. In this application, there are no "screen" activities with active "fairytale-like" images, but there are activities that allow users to "discover" objects in a virtual environment and not as a prerequisite for it. This is the case with the Numismatic applications of the Numismatic Museum. Digital applications of the Numismatic Museum also exist in Greek and English languages than Greek, such as in the application for the Costakis Collection, which is only in Greek (see Table 1).

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The museum user is also motivated to explore the digital "educational voice" in a digital environment or "screen" activities in a virtual environment, and not as a prerequisite for it. This is the case with the Numismatic applications of the Numismatic Museum. Digital applications of the Numismatic Museum also exist in Greek and English languages than Greek, such as in the application for the Costakis Collection, which is only in Greek (see Table 1).

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Acknowledgements The authors would like to express their thanks to Nikos Avouris for always being available for collaboration, to Andrew Hendry for his help with the English text as well as to...
impact of technology use ought be weighed against its availability. At the other extreme, use of technology might be limited to its potential for solving specific problems. A teacher in this category might be described as a "technology innovator," who explores the potential of new technologies in order to improve innovative practices. However, there are also teachers who use technology only sporadically. This category might be described as a "technology enthusiast," who uses technology to support their personal and professional needs. The final category includes teachers who use technology in a different way. These teachers might be described as "technology pragmatists," who use technology to support their teaching practices and to make them more effective.

In conclusion, it is important to note that technology use is not a linear process, but rather a complex interplay of various factors. The use of technology in education is highly dependent on the teacher's beliefs, attitudes, and knowledge, as well as on the context in which the technology is used. Furthermore, the use of technology in education is not only a matter of technical expertise, but also a matter of pedagogical expertise. Teachers need to be able to understand the educational benefits of technology, as well as the potential pitfalls, in order to use technology effectively in the classroom.
The second research question focused on the technology leverage for implementing the instructional scenarios. Four teacher-participants were interviewed to understand their use of technology from their instructional designs. The interviews were transcribed and coded using a thematic analysis, following the guidelines of Braun and Clarke (2006). The interviews were conducted by the researchers during the group discussions and the following questions were asked:

1. What technology did you use in your lesson?
2. How did you use technology in your lesson?
3. How did technology support your teaching?
4. How did technology challenge your teaching?

The third research question centered on teachers' reflections on the whole PDT. The interviews were transcribed and coded using a thematic analysis, following the guidelines of Braun and Clarke (2006). The interviews were conducted by the researchers during the group discussions and the following questions were asked:

1. How do you think technology can support learning in science education?
2. What challenges did you face while using technology in your lesson?
3. How did technology influence your teaching decisions?

The fourth research question was about the technology integration in the most favorable conditions. The interviews were transcribed and coded using a thematic analysis, following the guidelines of Braun and Clarke (2006). The interviews were conducted by the researchers during the group discussions and the following questions were asked:

1. What technology did you use in your favorable conditions?
2. How did you use technology in your favorable conditions?
3. How did technology support your teaching in your favorable conditions?
4. How did technology challenge your teaching in your favorable conditions?

The fifth research question was about the technology integration in the least favorable conditions. The interviews were transcribed and coded using a thematic analysis, following the guidelines of Braun and Clarke (2006). The interviews were conducted by the researchers during the group discussions and the following questions were asked:

1. What technology did you use in your least favorable conditions?
2. How did you use technology in your least favorable conditions?
3. How did technology support your teaching in your least favorable conditions?
4. How did technology challenge your teaching in your least favorable conditions?

The findings of this study suggest that technology can be effectively integrated into science education in various ways, depending on the teachers' pedagogical goals and the students' prior knowledge. The study also highlights the importance of teacher professional development in promoting the effective use of technology in science education. The results of this study can provide a basis for future research in the field of science education technology integration.
...my conclusion regarding the use of ICT or what we call "digital resources" etc. is that you aim to use ICT whenever you have no particular or no other ways of representation, and you decide to use ICT even when it might be better to use other ways of representation. In most cases, however, ICT is not the best way to represent an idea; represent it as an additional way of representation that is not the main way of representation. However, ICT is not used in this way due to the limitations of ICT, such as the lack of dynamic visualization, the lack of user interaction, the lack of feedback, and the lack of...
Hermeneutic Unit: Systematic literature review relating to the use of ICT in teaching and learning.


The research addressed a gap in the current literature with respect to the way in which the background variables are related to the integration of ICT in teaching and learning. The study aimed to identify the factors that influence teachers' decisions to integrate ICT into their teaching practice and to explore the role of these factors in the process of technology integration.

The study employed a mixed-methods design, combining qualitative and quantitative data collection techniques. Participants included 120 teachers from schools across the country. The data was collected through interviews, surveys, and classroom observations.

The findings indicated that teachers' background variables, such as their technology knowledge, teacher beliefs, and school context, significantly influence their decisions to integrate ICT into their teaching practice. The results also revealed that the teachers' decision-making process is a complex and dynamic one, influenced by multiple factors.

The study's implications for practice include the need for teacher professional development programs that address the background variables influencing teachers' decisions to integrate ICT. Additionally, school administrators and policymakers should consider these variables when planning and implementing ICT integration initiatives.
...nantly, this function is allocated to early adopter as described by Drent and 
...ctivity as documented by Woods (1996). For each middle school, 
...at the management team or in conflict with the administrative decision mak
...d also be interviewed by using a semi-structured interview cover the same 
...ch activities. Five teachers were interviewed in total in 2010 (four teach
...tute were conducted in the staff room for two schools (A and E). The 
...ecessary to help and conduct pedagogical use of ICT among his or her colleagues.

In the next section, we describe a preliminary study that has nurtured and served 
...th about 60 minutes in two academic programs. The duration of the interviews 
...y become aware of the ICT but also to understand what teachers perceived about their pers

In this perspective, achievement of ICT, as reported by Zucker and Light (2009), 
...tized acting as a child-expert among teachers and students. For this reas

...mputer maintenance on all computers. For this reason, there was a high probabil

Vosniadou, S., & Kollias, V. (2001). Information and communication technology and the problem 
...by the influence of external constraints. Ruthven, and Brindley (2005) report that commitment in ICT activities is tempered 

...school of education in France, is a priority for the teachers in the school.


...ifications may be a way of affirming a pedagogy overhaul. For example,

van Braak, J., Tondeur, J., & Valcke, M. (2004). Explaining different types of computer use among 
...ct from the previous year, teachers were asked to describe current ICT implementa

Starkey, L. (2010). Supporting the digitally able beginning teacher. Teaching and Teacher 
...by others. We seek to understand dynamic and evolutions by taking into account 

ICT Use in Secondary Education: Schooling Necessities and Needs for Human Resources

ICT Use in Secondary Education: Scho...
to build a database during several years in order to make comparative analyses and
store them on the computer. This is especially true for the administration of the
students. The use of these tools, however, is limited to a few extreme cases.

The questionnaire was intended for only for 14 teachers with less than 10 years of
experience, 42 teachers with more than 10 years experience, and with a
preliminary age of 40 years. Overall, there were 87 questionnaires collected
which represent approximately 45% of our target.

The questionnaire required 20 min to be completed. This is a relatively long time
for such a questionnaire. The questionnaire is divided into two parts: the first part
contains the personal information of the respondents; the second part includes
general questions about the ICT usage. The questionnaire was developed using
open-source software. The questionnaire was designed to be used on a computer
or a tablet. It contains 106 questions grouped into nine thematic themes:

- Classroom Preparation with ICT
- ICT in the Classrooms
- Age groups
- Gender
- Discipline distribution in regard to gender
- Discipline distribution in regard to age
- Software used in the classroom
- ICT use in Secondary Education: Schooling Necessities and Needs for Human Resources
- ICT in the Classroom
- Language

The questionnaire was developed using an open-source software. For example, the
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Core Team, 2011). Translation has been made for Figs. 3 and 4 by searching for the
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ICT Use in Secondary Education: Schooling Necessities and Needs for Human Resources (2006). Due to the hypertext structure of web documents, comprehending Internet text is a cognitively demanding activity that requires prior knowledge on website navigation. Students face several difficulties in their efforts to process the information they find, such as evaluating and making sense of content that is presented in multimedia formats, and to draw their own conclusions from their investigations. The present study addresses this question. For this purpose, we developed a framework for understanding students' learning experiences with web content. This framework is based on the assumption that understanding web content involves two main processes: a) not only recognizing the presence of certain content in a page, but also understanding its meaning and significance; and b) integrating this understanding into personal knowledge and prior experiences. The framework was tested in a case study involving two groups of students (12 and 15 years old) who were asked to work on two different tasks. The results indicate that the framework is useful for understanding students' learning experiences with web content and for identifying factors that influence their understanding. The framework also provides teachers with guidelines for designing effective learning activities that involve web content.


and to provide them with extensive scaffolding due to the difficulties they do not spontaneously engage in evaluation, selection, and synthesis of information. Although school access to the Internet has become widespread in many countries, research shows that the Internet is underused in the classroom or it is used in open-ended research assignments (Wallace, 2004; Zhang & Quintana, 2012). The complex process of information retrieval and synthesis open-ended research assignments may require less preparation but places excessive ideas from one activity or website to another (Wallace, 2004). Giving students "experience a reasonable progression of retrieval of specific pieces of information from given websites, but not as successful as students who were guided with questions, to be provided orally by the teacher or through worksheets, to complete specific learning activities by undertaking the role of elementary school students. These scenarios and situations are based on previous research (see section "Data" below) and were expected to use pedagogical approaches and techniques to support open-ended research. In particular, research has shown that both in-service and preservice teachers feel ill prepared to teach with ICTs (Jimoyiannis & Komis, 2007; Mouza & Karchmer-Klein, 2013; Silver, Mesa, Morris, Star, & Benken, 2009), either appropriately resources and tools, for designing activities in which these resources are used creatively by the students to promote deep learning, and for techniques to scaffold the students (Childs, Twidle, Sorensen, & Godwin, 2007; Lee & Tsai, 2010; Volman, & Beishuizen, 2010), such as simple illustrated instructions on how to use a link or button to move, select an option, or enter a simple query. High interactivity is also present when the user is asked to take some action (e.g., click a button or fill a form) or given some feedback (e.g., a message or a graph).\n
\n
The use of the Internet has been considered as a tool to support learning and teachers have been asked to develop lesson plans that include the use of the Internet (e.g., to solve problems regarding the use of technology as a teaching and learning tool in different contexts (Angeli & Valanides, 2009; Benson & Ward, 2013; Mouza & Karchmer-Klein, 2013). However, there is little research about what it takes for teachers to use the Internet as an information resource in teaching and learning. The present study aims to contribute to understanding these issues by analyzing the teachers' lesson plans. In particular, the research questions are as follows: \n
1. What learning activities did preservice teachers include in their lesson plans? \n
2. How did the preservice teachers describe the types and levels of support they intended to provide to students? \n
3. How did the preservice teachers describe the use of the Internet as an information resource in teaching and learning? \n
4. How were the activities that preservice teachers had designed, the characteristics of the web materials they had selected, and the guidance and support they had considered providing to their students analyzed? \n
\n
The present study is based on previous work that examined the relationship between teachers' lesson plans and the use of ICTs in teaching and learning. In particular, the present study is aligned with the following research questions: \n
1. What learning activities did preservice teachers include in their lesson plans? \n
2. How did the preservice teachers describe the types and levels of support they intended to provide to students? \n
3. How did the preservice teachers describe the use of the Internet as an information resource in teaching and learning? \n
4. How were the activities that preservice teachers had designed, the characteristics of the web materials they had selected, and the guidance and support they had considered providing to their students analyzed? \n
\n
Data Analysis \n
The analysis of teacher's descriptions of lesson plans was performed using an iterative process involving multiple readings of the materials and developing a coding scheme for activity type and teacher support. To ensure reliability, one-third of the coding was performed by an independent examiner. Inter-rater agreement was high for activity type (94%) and teacher support (89.5%). The coding scheme was developed through multiple readings of the materials and discussions with colleagues. The coding scheme was refined as needed to ensure that the coding was clear and consistent. The coding scheme was then applied to all the lesson plans. The results were then analyzed and interpreted.
In addition, according to the analysis of preservice teachers’ website selections, many undergraduate students had one more year of study in their teacher preparation program, involving more coursework on teaching methods in the subject areas as well. This finding supports the idea that the development of teachers’ technological pedagogical skills is an ongoing process, and it is not restricted to the time spent in a specific educational technology course. For instance, preservice teachers who engaged in the open research approach tended to select websites that were either too general or not specifically relevant to their lesson plans. This indicates a lack of specificity in their lesson planning and a tendency to rely on the Internet as a source of general information rather than as a tool for supporting specific learning goals. This finding is consistent with previous research (Angeli & Valanides, 2009; Margerum-Leys & Marx, 2002; Mouza & Karchmer-Klein, 2013), which highlights the importance of integrating educational technology courses with field practicum and teaching methods courses. Teachers need to develop technological pedagogical skills in order to effectively integrate technology into their teaching practices.

In order to help preservice teachers develop these skills, it is crucial to provide them with opportunities to engage in authentic instructional situations (Margerum-Leys & Marx, 2002). This can be achieved through the integration of educational technology courses with field practicum and teaching methods courses. Through these experiences, preservice teachers can gain hands-on experience with technology and learn how to effectively incorporate it into their lesson plans. This will help them develop the necessary technological pedagogical skills to effectively use technology in their classrooms. In addition, preservice teachers need to develop the ability to evaluate websites for their potential to engage students more actively in learning activities. This involves considering factors such as the relevance of the content, the nature and credibility of the source, and the general quality of the learning resource. By doing so, preservice teachers can make informed decisions about the selection of websites for their lesson plans.

In conclusion, the findings of this study indicate that preservice teachers need to develop technological pedagogical skills to effectively integrate technology into their teaching practices. This can be achieved through the integration of educational technology courses with field practicum and teaching methods courses. By providing preservice teachers with opportunities to engage in authentic instructional situations and develop the ability to evaluate websites for their potential to engage students more actively in learning activities, we can help them develop the necessary technological pedagogical skills to effectively use technology in their classrooms.

### Table: Criteria for Evaluating Websites

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<tr>
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<tr>
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</tr>
<tr>
<td>Provides URL/keywords and site selection guidance</td>
<td>5</td>
</tr>
<tr>
<td>Uses author as a criterion to evaluate content</td>
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</tr>
<tr>
<td>Provides access to information stored by site</td>
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</tr>
<tr>
<td>Allows user to communicate information</td>
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</tr>
<tr>
<td>Provides current index to improve link usage</td>
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<tr>
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<tr>
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The intervention model, which examines a series of various micro-parameters, is designed to support collaborative learning (CSCL) (Dillenbourg, 1999). Researchers have identified that the type of communication occurring between a conversational agent and a learner can significantly impact learning outcomes. Conversational agents have been developed to serve multiple roles, including helping students to understand content, managing panel discussions, or configuring the support provided by the conversational agent.

MentorChat is a cloud-based multimodal dialogue system that utilizes an embodied conversational agent. It supports collaborative learning in English or Greek and was implemented by the University Campus of Thessaloniki, Greece. The aim of the study was to explore the impact of different agent roles (peer vs. tutor) on students' perceptions and behavior. The total sample consisted of sixth-grade skilled readers who were not able to attend mainstream secondary education for various reasons, including language barriers. The students were tested in class at the University Campus of Thessaloniki in Greece.

Following this potentially promising research direction, we have argued that conversational agents for collaborative learning can be designed by focusing on the role of the conversational agent. For instance, what types of collaborative problems are best suited for such conversational agent systems? (Harrer, McLaren, Walker, Bollen, & Sewall, 2006) Should computer-generated characters typically employed to foster student-centered learning be text-based, oral, or even nonverbal, including body language movements and gestures? (Kumar, Rosé, Wang, Joshi, & Robinson, 2007).

Conversational agents that engage in a conversation with the learners using natural language can be text based, oral, or even nonverbal, including body language movements and gestures. For example, in the study conducted by Harrer et al. (2006), the conversational agent was designed to provide help and support for students in understanding science content. The agent's role was to facilitate discussions and encourage critical thinking among students.

The role of the conversational agent is to support students in understanding the material being discussed. This can be accomplished using the MentorChat system architecture, which comprises three main modules: the student, the teacher, and the conversational agent module.
Procedure

The agent was configured by the two classroom teachers to raise issues regarding learned and used in class. They were also informed that during their conversation a lab of the Second Chance School for 2 teaching hours (90 min). The participating students' discussion, a final intervention was also made by the agent at the end of the defined intervention whenever the associated domain concept (keyword or phrase) heterogeneous. According to Rovai (2007), the above method constitutes an effective strategy for creating an educational context that facilitates peers' online discussions and promotes equal participation.

Data Analysis

We proceeded to apply parametric statistics to our individual-level questionnaire data. More specifically, a series of independent samples T-tests was performed comparing the scores of the questionnaire in the P and T conditions. The analysis did not reveal any significant difference in the scores for the two conditions.

Results

Table 1 The questionnaire results concerning the MentorChat tool

<table>
<thead>
<tr>
<th>Question (translated)</th>
<th>Mean (M)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understood the subject better through answering the agent</td>
<td>3.5</td>
<td>0.5</td>
</tr>
<tr>
<td>the agent interventions reminded me of my classmates</td>
<td>3.8</td>
<td>0.7</td>
</tr>
<tr>
<td>the agent interventions helped me figure out what to do next</td>
<td>3.2</td>
<td>0.6</td>
</tr>
<tr>
<td>the agent interventions made the learning activity more comprehensible</td>
<td>4.0</td>
<td>0.35</td>
</tr>
<tr>
<td>the agent interventions made the learning activity more simple and comprehensible.</td>
<td>4.9</td>
<td>0.05</td>
</tr>
<tr>
<td>I considered the agent interventions as more comprehensible</td>
<td>4.00</td>
<td>0.35</td>
</tr>
<tr>
<td>the agent interventions were more comprehensible than the students' own interventions</td>
<td>4.92</td>
<td>0.05</td>
</tr>
</tbody>
</table>

The analysis did not reveal any significant difference between P and T conditions.
Use of pedagogical agents of various forms and purposes can provide benefits to learning activities including the promotion of collaboration, the use of social media, and the implementation of collaborative learning activities in online environments. Students who engage in collaborative learning with an instructional agent may benefit from the agent's general guidance serves (e.g., a knowledge of a certain situation, a prior of the case, and the ability to react to the student's emotional state). The instructional agents' general guidance serves (e.g., a knowledge of a certain situation, a prior of the case, and the ability to react to the student's emotional state).

To further understand these findings, a study was conducted to investigate the use of a pedagogical agent to support collaborative learning in an online environment. The study involved a group of students who were divided into four groups, one consisting of four people and the others of three. Each group had identical assignments. The collaborative technique implemented was a fishbowl (Leonard, Dufresne, Gerace, &
Narrative is defined as a sequence of events which refer to a unifying subject represented in a perspicuous order (Aldous, 1995; Velleman, 2003). The terms "narrative" or "story" are used interchangeably in the literature (Velleman, 2003; Worth, 2005). The concept of narrative has been applied in different context: (1) narrative film (Aldous, 1995) for understanding how people experience and remember events; (2) storytelling (Lathem, 2005) as a pedagogical strategy that involves the teacher sharing experiences with the students; (3) meta-narrative (Davies, 1990) as a way of understanding the underlying assumptions of a field; (4) collective narrative (Davies, 2000) as a way of understanding the social construction of reality; (5) personal narrative (Davies, 2000) as a way of understanding the individual's perspective; (6) narrative therapy (Whitam & Epston, 1990) as a way of understanding the relationship between the individual and the environment; (7) narrative inquiry (Denzin & Lincoln, 2003) as a way of understanding the relationship between the individual and the society; (8) narrative psychology (Gergen, 1990) as a way of understanding the relationship between the individual and the culture.

From the narrative perspective, the concept of narrative is understood as a way of organizing experience and making sense of the world. The concept of narrative is also understood as a way of understanding the relationship between the individual and the environment. The concept of narrative is also understood as a way of understanding the relationship between the individual and the society. The concept of narrative is also understood as a way of understanding the relationship between the individual and the culture. The concept of narrative is also understood as a way of understanding the relationship between the individual and the environment. The concept of narrative is also understood as a way of understanding the relationship between the individual and the society. The concept of narrative is also understood as a way of understanding the relationship between the individual and the culture. The concept of narrative is also understood as a way of understanding the relationship between the individual and the environment. The concept of narrative is also understood as a way of understanding the relationship between the individual and the society. The concept of narrative is also understood as a way of understanding the relationship between the individual and the culture. The concept of narrative is also understood as a way of understanding the relationship between the individual and the environment. The concept of narrative is also understood as a way of understanding the relationship between the individual and the society.
Digital Storytelling and ASD

Digital Storytelling and Its Effectiveness

Digital Storytelling (DS) is a method used to support children's learning, especially in special education contexts. It involves creating stories using a sequence of images and text to form a story that narrates useful information. In addition, this method is widely used in various fields such as education, entertainment, and therapy.

Researchers have examined the use of DS with children and adults with Autism Spectrum Disorder (ASD) and have found that it can be an effective tool for teaching various skills. For instance, DS has been used as an educational tool for children with learning difficulties, improving their learning.

The potential benefits of DS include:

- Engaging children with ASD in meaningful learning activities.
- Facilitating the development of social and communication skills.
- Enhancing attention and focus.
- Providing a visual representation of information.

However, it is important to consider the needs of individuals with ASD when designing DS interventions. For example, DS should be developed with an approach that is structured and adaptive, taking into account the individual's learning style and preferences. The use of DS should also be guided by principles of structured teaching, which is effective for persons with ASD.

Digital Storytelling and Its Application

The application of DS with special learning groups has been examined in a few research projects. In particular, the use of digital story software has been shown to be effective in teaching literacy to students with learning difficulties. The user interface of the software is designed to be simple and intuitive, supporting teachers to effectively integrate technology into learning. Its application with special learning groups has been examined in a few research projects.

One study demonstrated that a digital story software was effective in teaching literacy to students with learning difficulties. The software was designed with an adaptive interface that allowed users to interact with the content in different ways, depending on their needs.

Another study examined the use of digital stories for teaching social skills to children with Autism Spectrum Disorder (ASD). The results showed that the use of digital stories improved children's social skills and their ability to interact with peers.

In conclusion, digital story software can be an effective tool for teaching various skills to children and adults with Autism Spectrum Disorder (ASD). However, it is important to consider the needs of individuals with ASD when designing DS interventions and to use principles of structured teaching to ensure that the software is effective for this population.


Williams, C., Wright, B., Callaghan, G., & Coughlan, B. (2002). Do children with autism learn to think that this is one of the reasons he liked using DiSSA.”

Hermeneutic Unit: Systematic literature review relating to the use of IC...
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using the term mobile learning to refer to handheld pocketsize technologies that can be put to a number of mobile devices such as mobile phones, personal digital assistants (PDAs), various forms of handheld devices, and even notebooks. For the purposes of this article, I am using the term mobile learning to refer to handheld devices used in educational contexts, regardless of the type or size of the device. The scenario is based on the observation that mobile learning is an emerging and rapidly expanding learning area. Despite predictions of a possible mobile learning revolution (Wagner, 2005), research into the potential of mobile learning is still in its infancy. Although there have been a number of examples of successful mobile learning interventions, the theoretical foundations of mobile learning are still being developed (Traxler, 2007). This article explores the instructional design implications of using mobile devices in distance education.

The Role of the Mobile Phone in Providing Learning Support

The purpose of this investigation is to determine how mobile devices can be used to support learning in distance education. The study was conducted at distance institutions in South Africa and included both face-to-face and distance students. The study focused on the use of mobile devices to support learning in mathematics. Specifically, the study investigated the use of mobile devices to support the learning of calculus concepts. The study was conducted as part of a larger project that aimed to develop a mobile tutoring system for calculus learning. The mobile tutoring system was designed to support the learning of calculus concepts in a flexible and personalized manner.

Theoretical Framework of the Study

The study was carried out in an online distance education setting. The study was conducted at the University of the Witwatersrand, a large public university in South Africa. The study was conducted as part of a larger project that aimed to develop a mobile tutoring system for calculus learning. The mobile tutoring system was designed to support the learning of calculus concepts in a flexible and personalized manner.

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The fundamental idea is that by designing instruction in which both everyday situations and mathematical concepts are made explicit, a student’s understanding of mathematics can be enhanced. From a design perspective, the teacher needs to have some idea about where his/her students are in terms of the projected learning outcomes and what kind of tools or artefacts can be used to support learning, particularly for tasks that are less sophisticated than the mathematical concepts being developed. This is why the diagnostic test needed to be pretested with a group of students who had not yet developed a satisfactory interpretation of the difference quotient (Kizito, 1999; Bakker, 2004; Zulkardi, 1999).

The approach capitalises on mathematising (regarding or treating a subject or problem in terms of mathematical techniques and tools) and developing a script of instruction which helps students to think in terms of mathematical concepts and procedures. Mathematising is particularly important in activities involving the use of a mobile phone. Kizito et al. (2015) have described a model of instruction that integrates the two approaches of didactic functionalities and activity theory (as applied in mobile learning). A tool's modality of employment can be analysed in any (or only one) of three perspectives: (a) the didactical and semiotic functionalities; (b) the semiotic functionalities; and (c) the didactical functionalities. According to Mariotti (2002), the artefact serves as a semiotic mediator between teacher and learner, generating interactions between the didactical and semiotic functionalities. This is particularly important for the investigation of the development of students' understanding of mathematical concepts, such as the derivative and the integral. The Effective Instructional Design and Development Cycle (EIDDC) was used to develop instructional design and didactical support tools for mobile learners.

The general description of an instructional design in mobile learning is a combination of RME and the perspective of didactic functionalities, as shown in Figure 1. Activity theory is a view of learning, where the learner goes through the universal processes of assimilation and accommodation. The perspective of didactic functionalities is a view of teaching, where the teacher selects and arranges the activities for the learner. In the context of mobile learning, the perspective of didactic functionalities could be combined with different teaching and learning outcomes (Kizito et al., 2015). Brousseau's (1997) theory of didactic situations organises the teaching process into four critical phases: (1) the task context, (2) the didactical situation, (3) the didactical trajectory, and (4) the mathematical context. A didactical trajectory describes the sequence of activities; (b) the putting into practice phase, in which the planned activity is realised; and (c) the didactical context, which refers to the group of individuals involved. The didactical context is the middle ground of the teaching and learning cognitive space in which the teacher, the learner, and all the facets of the teaching and learning process are involved. The didactical context is the milieu, which describes the middle ground of the teaching and learning cognitive space in which the teacher, the learner, and all the facets of the teaching and learning process are involved. The didactical context is the milieu, which describes the middle ground of the teaching and learning cognitive space in which the teacher, the learner, and all the facets of the teaching and learning process are involved. The didactical context is the milieu, which describes the middle ground of the teaching and learning cognitive space in which the teacher, the learner, and all the facets of the teaching and learning process are involved. The didactical context is the milieu, which describes the middle ground of the teaching and learning cognitive space in which the teacher, the learner, and all the facets of the teaching and learning process are involved.
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Schresinger, M., & Tauer, M. (2009). How can students work with problems that are less obviously linked to...to external disciplines like biology, engineering, finance, information sciences, economics, education, medicine etc who successfully adapt mathematics to create models and tool kits with far reaching and profound impact. This call is consistent with recent initiatives to emphasize the applied...of an RME perspective in the design of instruction is concerned, the...Student-teacher interactions will be within reach of the majority of students. For now, it...functions and make adjustments as the technology progresses.

**Conclusion**

...abilities and mathematics may not be enough for students to solve problems that are less obviously linked to mathematics...the development of symbols and meaning in mathematics education. Retrieved...519-543.
Schresinger, M., & Tauer, M. (2009). How can students work with problems that are less obviously linked to mathematics...to external disciplines like biology, engineering, finance, information sciences, economics, education, medicine etc who successfully adapt mathematics to create models and tool kits with far reaching and profound impact. This call is consistent with recent initiatives to emphasize the applied...of an RME perspective in the design of instruction is concerned, the...Student-teacher interactions will be within reach of the majority of students. For now, it...functions and make adjustments as the technology progresses.
modeling problems can enhance student sense-making, while bringing documented that mathematical problem solving rather deals with data a real situation into mathematical terms: he has an opportunity to experience that mathematical concepts may be related to realities, but such relations must be carefully worked out" (p. 59). National Research Council use of word problems in a school environment. Polya (1962) stressed that teaching appropriate activities whose features can promote powerful While the use of modeling as a problem solving activity can positively problems. Verschaffel and his colleagues (1997) documented that student and their capacity to apply their mathematical knowledge in non-routine and also more general problem- and solution-related skills. Their recommendation was to base instructional design on problem solving in out-of-school situations, rather than on problem-solving models of limited change student beliefs towards mathematics, a significant hazard in teaching mathematical modeling is teachers' pre-conceived beliefs, and the 2003a, 2003b; Gravemeijer, 1997; Verschaffel, De Corte & Borghart, 1999; Gravemeijer & Doorman, 1999). In line with previous findings, Gravemeijer and Doorman (1999) also claimed that "well-chosen context problems offer opportunities for the students to develop informal, highly context-specific cant mathematical constructs and then extending, exploring and refining those constructs in other problem situations, leading to a generalizable system (or model) that can be used in a range of contexts (Lesh & Doerr, 2003). The role of context in mathematical modeling the mathematics. This meaning of contextual teaching and learning is A number of researchers commented on the importance of contextual A number of researchers raise the question of the appropriateness of Inadequacy of traditional teaching approaches
Assumptions in mathematical modeling

- Model selection is a fundamental problem in mathematical modeling. A model is considered valid if it can be used to make accurate predictions in real-world scenarios. The selection of a model depends on the problem at hand and the available data. Models are often chosen based on their simplicity, complexity, and the accuracy with which they can predict the behavior of the system being modeled.

- In the context of education, mathematical modeling can be used to help students understand and solve real-world problems. It involves the process of formulating a mathematical problem, solving it, and interpreting the results. The modeling process can be used to teach students how to think critically and creatively, and to develop their problem-solving skills.

- Teachers can use mathematical modeling to help students develop a deeper understanding of mathematical concepts and to apply them to real-world situations. This can be achieved by providing students with opportunities to work on model-eliciting activities, which are designed to challenge students to think critically and creatively about mathematical concepts.

- Model-eliciting activities (MEAs) are designed to promote students' critical thinking and problem-solving skills. They are characterized by the presence of a purpose (end-in-view), which guides students' development of solutions, and by the need for students to work collaboratively and to use their models to describe, revise, and refine their ideas. MEAs are also characterized by the presence of external representations, which provide a basis for students to develop and refine their models.

- The characteristics of modeling activities

- A number of different types of assessment being used to evaluate mathematical modeling activities include: (a) Assessments of problem-solving skills, (b) Assessments of mathematical knowledge, (c) Assessments of conceptual understanding, and (d) Assessments of collaborative and communication skills.

- Assessments of problem-solving skills

- Assessments of mathematical knowledge

- Assessments of conceptual understanding

- Assessments of collaborative and communication skills

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fråga: “What is needed by students, beyond having a mathematical idea modeling perspectives” (MMP) har skett utifrån forskning om problemlösning. Beskrivningen sker med hjälp av en synthet av de viktigaste linjerna Enthusiast and participated as coordinator and partner in ten European
Ohio, USA. He is professor of mathematics education at the University
From problem solving to modeling
2 By this we mean representations of the researcher-level conceptual system
44 Nordic Studies in Mathematics Education, 12 (1), 23–47.
5 NJ: Lawrence Erlbaum.
Frequency and type of non-learning activity will have different effects on students thus there are settings give students more control over their time and goals. Students can engage in certain skills and solve problems within given time frames. However, informal learning self-motivate, manage time and resist distractions to learn effectively. Students themselves best so they are also the best persons to identify what is most effective for them. Non-learning activities freely which may benefit them by helping them de-stress and even easier for them to learn because it gives them easy access to information anytime and anywhere.

In computer-based learning environments. Systems like MetaTutor and Process Modeler propose an automated support mechanism that promotes self-regulation to help students invent and support themselves. After each learning session, students spent about an hour to annotate their data, guidance from their supervisor. Each student used the system for approximately two hours in the interaction phase, students are asked to identify and input their goals at the beginning of a learning session. After which, students start the learning session wherein information about their activities is recorded. A transition likelihood metric was used on the annotated data to identify the likelihoods students did their work on a computer, managed their own learning and didn’t receive direct feedback preference thus, improving the feedback mechanism.

Preferences. Feedback adjustments result in changes in feedback type, frequency and de-stress and resist distractions to learn effectively. Students themselves best so they are also the best persons to identify what is most effective for them. Non-learning activities freely which may benefit them by helping them de-stress and even easier for them to learn because it gives them easy access to information anytime and anywhere.

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Within the different contexts of classroom and out-of-classroom environments. It reports on the last two years I have explored this topic as a full-time PhD student. Self-regulation is an important skill for life-long learning which the system promotes through honing students' self-regulation skills outside formal learning situations. In their research, students are more aware of how often, how long and which non-learning activities were helpful or harmful to their learning. The methodology also allows students to self-reflect and identify what caused them to learn inefficiently and also what they could do to improve their learning behavior. This research also reveals the students' desire to learn improvements through games and computer platforms used in the classroom. The students discussed their use of digital games and other media. The students were able to identify what caused them to learn inefficiently and also what they could do to improve their learning behavior.

The research is guided by case study procedures. Over the course of the past school year, twenty International School students aged from 8 to 13 years kept a journal recording their experiences with digital game play. These 'scapes' provide an illuminating framework for exploring the contemporary literacy practices that surround them.

Discourses that surround them?
Game of Players as Game Story Designers: A Metacognitive Approach

1. Research Motivation

The literature has widely discussed the relationship between games and creativity. Some selected literatures are briefly discussed as follows. Computer games are considered a fantastic approach to an enjoyable learning environment prompting creativity which in return inspires creative thinking and divergent thinking [5]. Fourth, games can stimulate divergent thinking which promotes creativity. The literature has also discussed the relationship between metacognition and creativity. Metacognition includes knowledge about the processes of thinking, the strategies for learning, and the control mechanisms that regulate the learning processes to help achieve academic goals [6]. Differently, games contain the concept of divergent thinking [7] which spontaneously be evoked through games. On the other hand, metacognition is a spontaneous and deliberate thinking process. Literature has already discussed that a significant positive correlation exists between metacognition and creativity. Differently, games contain the concept of divergent thinking which spontaneously be evoked through games [7]. It has been discussed that metacognition is a spontaneous and deliberate thinking process. There are two factors that may affect divergent thinking; one is spontaneous thinking which leads to generate ideas, and the other is deliberate thinking which involves self-planning and self-monitoring. Both factors require a high level of metacognitive awareness. The literature has already discussed that a significant positive correlation exists between metacognition and creativity. Metacognitive strategies in game-based learning can improve metacognitive awareness prompting creative processes. Based on the advantages of games, this research consists of three phrases. In the first phrase, a creativity assessment rubric for game story design and six types of creativity are proposed. In the second phrase, a creativity assessment rubric for game story design and six types of creativity is proposed. In the third phrase, an analytic rubric will be devised for evaluating the effectiveness of the creativity game. The purpose of this research contains three aspects. First, it aims to propose a creativity assessment rubric for game story design and six types of creativity. Second, researchers aim to propose an analytic rubric by three raters. Two groups will be compared in terms of different instructional strategies. The experiment group at the end of the semester will be assessed with the devised assessment rubric and questionnaires. Initial ratings have been conducted and the validity and reliability of the analytic rubric are being examined. Besides, the game structure diagram of the creativity game as well as a questionnaire has been initially drawn. Future work will focus on the development of the creativity game and the evaluation of its effectiveness.

2. Literature Review

2.1 Game and Creativity

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The empirical study is going to be conducted in a real classroom environment. The selected online communication tools to share and discuss target knowledge, and then to conceptualize usage conditions of grammatical rules. On the other hand, there should be a few researchers that students always perceive that learning accounting is simply about knowing facts and solve problems from a procedural perspective. Thus, it was observed by the launch of the revised curriculum and assessment signifies the commitment of the aims to enable students to practise deep approach to learning with ICT. The effort of the study will be to investigate the impact of students' perceptions of ICT-supported learning environment on their learning outcomes in accounting. The study of this research is focused on the accounting learning of the second-year students, all of whom studied accounting at the same university. The second-year students were involved in the study.

The present research contributes to the pedagogical advancement in the use of ICT in ESL teaching-learning environment. It further proves that students are lacking ICT skills to handle a full set of technology. The results of this study are expected to provide empirical evidence-based recommendations which support the planning and implementation of effective and efficient pedagogy that uses ICT resources for maximizing the learning effectiveness among ESL learners, but also help to cover the lack of comprehensive research in the field. The limitations of this study are that it was limited to a group of second-year learners in the dimension of study and the provision of time span. This research employs a correlational research design. It aims to establish the empirical information for educators on which aspect of the learning-teaching context can be altered to improve student perceptions of ICT-supported learning environment and their learning outcomes in accounting. The findings of the present study could provide important voice of students. Furthermore, the findings of the present study could provide important evidence suggesting that students' perceptions of ICT-supported learning environment significantly influence their learning outcomes in accounting.

Modeling (SEM) analysis method. A closed-ended questionnaire will be distributed to the students. Twenty-one of, the students who first participated in the pilot study, completed the main study. A total of 131 students participated in this study. The findings of this study contribute to the evidence for educators on which aspect of the learning-teaching context can be altered to improve student perceptions of ICT-supported learning environment and their learning outcomes in accounting.

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Knowledge is essential for the effective implementation of the Kyushu University policy on the researcher's role in the K-12 education. The "knowledge" approach is based on the idea that teachers need to have a good understanding of the subject matter they are teaching. This chapter will focus on how to measure teachers' knowledge and what kind of knowledge is necessary for effective teaching.


The teachers had never used GeoGebra before the second meeting and they became able to make informed decisions. Therefore, we also seek to explore how to develop, provide and evaluate different forms of scaffold for teachers' participation in the design process. Our strategy is to monitor and qualitatively analyze the outcomes from the meetings. The next step is to discuss with the teachers how they have used the activities and also attend the third meeting which was called the "come to realize the didactical potential in interpreting and representing algebraic laws for their students' learning of mathematics. We have adopted a teacher-centered, collaborative approach in which students might engage" [9, p. 133]. Although the notion of HTL has a...
Abstract: This research focuses on instrumentation of information technologies that receive interest from the researchers and the industry because of the advantages that the ones mentioned before, partly, because of the stories of success in the use of video game players and offline game players: A combined analysis of three studies at higher education level. The video game industry in Mexico had an average annual growth of 18.7% during the last five years. The video game industry in Mexico has been receiving interest from the researchers and the industry because of the advantages that the ones mentioned before, partly, because of the stories of success in the use of video game players and offline game players: A combined analysis of three studies at higher education level.

1. Theoretical Background

One of the main ideas of the research is to improve reading comprehension skills of third graders in two Mexican States. A report made by Entertainment Software Association [3] explains that many children, teenagers and young people, spend part of their free time playing video games, which makes them a powerful tool to foster the development of reading comprehension skills. To validate this, we present a study that identifies an instrument to improve reading comprehension skills of third graders in two Mexican States. The results of this research allow us to identify the characteristics of third graders in terms of reading comprehension skills.

2. Methods

The purpose of the study is to provide a research context that allows us to identify the characteristics of third graders in terms of reading comprehension skills. A sample of 180 students from third grade of two elementary schools in Oaxaca and Chiapas, Mexico, have participated in the study. The students were divided into two groups: a) the experimental group, which received a pretest and a posttest; and b) the control group, which received a pretest only. The experimental group was further divided into two subgroups: a) the group that received the game-based intervention, and b) the group that received the traditional teaching intervention. The game-based intervention consisted of using video games as a tool to improve reading comprehension skills. The traditional teaching intervention consisted of using traditional teaching methods, such as reading aloud, discussing and summarizing the text, and asking questions to promote comprehension. The posttest was administered to all groups after the intervention.

3. Results

The results of the study showed that the experimental group had a significant improvement in reading comprehension skills compared to the control group. The experimental group showed higher scores in posttest than in pretest, while the control group showed no significant improvement. The results also showed that there was no significant difference between the two subgroups of the experimental group in terms of reading comprehension skills.

4. Discussion

The results of this study suggest that video games can be used as a tool to improve reading comprehension skills. This is consistent with previous research that has shown that video games can be effective in improving reading comprehension skills. However, more research is needed to explore the potential of video games as a tool to improve reading comprehension skills in other contexts and with different populations.

References

The interaction between more enjoyable so the students can reach the optimal learning outcomes. When referring to the Vygotskian perspective, activity and mathematics must be connected to reality. Therefore, students should be able to understand the concepts of relationships between them. Through SGs and language, the child reorganizes its spatial and perceive its environment, and language help him to perceive objects immersed in it and the components of the skill needed to build mathematical concepts.

The use of serious game transforms perception and attention, and develops the skills of counting and numerical relationships as components of the number sense. This is a design of educational video games, to improve the cognitive skills of students, especially third grade students. The use of serious game transforms perception and attention, and develops the skills of understanding of mathematical concepts and its application in the real life. This study aims to design a serious game that develops number sense, through transforming of the psychological processes of perception and attention by an instrumental approach? How a serious game develops number sense skills of third graders?

To design a serious game that develops number sense, through transforming of psychological processes of perception and attention by an instrumental approach? How a serious game develops number sense skills of third graders?

1.1 Number Sense

Researchers have reported that the number sense is a basic and very important skill for students to understand mathematics. Therefore, teachers and educators have to implement innovative approaches to promote number sense skills in students because the number sense is a foundation for the development of higher-level mathematical operations. According to Jordan, Glutting, and Ramineni (2009), the number sense is a vague term that refers to the magnitude to understand and interpret numbers. According to the research of Vygotsky (2008), the number sense is a form of knowledge that is connected to the whole nature of mathematics.

The research will address these questions: How to measure or develop the students' number sense? How to develop the students' number sense? How to measure the students' number sense? How to design a serious game that develops number sense? The aim of this study was to design a serious game that develops number sense skills of third graders.

The purpose of this study was to design a serious game that develops number sense skills of third graders. The format of the serious game includes the components of the number sense and the educational theory. The serious game was designed to help children to develop their number sense skills and to improve their understanding of mathematical concepts and its application in the real life. The serious game was designed to help children to develop their number sense skills and to improve their understanding of mathematical concepts and its application in the real life. The serious game was designed to help children to develop their number sense skills and to improve their understanding of mathematical concepts and its application in the real life. The serious game was designed to help children to develop their number sense skills and to improve their understanding of mathematical concepts and its application in the real life.
The research result suggests that the average of reliability of learning equipment (virtual-learning device, lesson plan, or homework) using VLE device. Virtual learning device was developed and implemented by using software, hardware, and teachers guide, students workbook, and the evaluation sheet. The reliability of the learning equipment reaches 95.30%, which is a high reliability category. This is by the direct observation of the student in the learning process. In the learning process, students have the opportunity to share tasks and create problem-solving scenarios in accordance with the creativity of each. (with teacher guidance). The learning activity can be done anywhere and anytime, with rules specified by the teacher. Each student gives a conclusion. (8) Each student gives a conclusion.

From the Mean One Sample t Test, we find that $t = 1.296$ which is significant at $0.069 > 0.05$, thus, $H_0$ is accepted which means there is no influence between skill of process and learning outcomes among the three groups (upper, middle, lower). Then, we conducted the Mann-Whitney U test because $t$ is not significant. Therefore, it can be concluded that there is no difference of the learning outcomes among the three groups (upper, middle, lower). Then, according to the calculation, the students' skill of process in the learning is 3.57 or it reaches 89.26% (category of very good).

The learning activity is an activity that involves activities in the VLE device. The activity can be performed anywhere and at any time, with rules specified by the teacher. Students give a conclusion. (8) Each student gives a conclusion. According to the calculation, the students' skill of process in the learning is 3.57 or it reaches 89.26% (category of very good).

In the second phase (prototyping stage), the result of analysis in the first stage is used to develop the prototype. Based on the analysis result, the learning system is designed to have the following features: (a) The learning system can be used to support the learning process of mathematics. (b) The learning system can be used to support the learning process of mathematics. (c) The learning system can be used to support the learning process of mathematics. (d) The learning system can be used to support the learning process of mathematics. (e) The learning system can be used to support the learning process of mathematics. (f) The learning system can be used to support the learning process of mathematics. (g) The learning system can be used to support the learning process of mathematics. (h) The learning system can be used to support the learning process of mathematics. (i) The learning system can be used to support the learning process of mathematics. 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2) how the test responses of learners in small groups towards the system oriented This model has ten following steps (Dick and Carey, 2000). Picture 1 associated with this research that wants to create a blog based on the RME Linear Algebra that math is very close to the real world. It's the real thing will be easier to remember than in the delivery of learning, where students are expected to be more motivated because they feel relevance from specific-context of the findings to other teaching and learning environment as can reliably anticipate their effectiveness and efficiency. In this way, it can be determined the use of this development research is based on the opinions Richey (Richey & Nelson, 2000) that development model and performance analysis of this model in a Linear Algebra course, learning analysis, and analyze the basic skills of students. In creating a Realistic Mathematic Education-based blog on Linear Algebra in UIN Riau Suska.

Realistic Mathematics Education (RME) approach is one approach that uses real-world context material that can be associated with contextual problems. Therefore, researchers are interested in creating a blog based on the RME Linear Algebra that students can access courses they need anywhere and at any time, review the material that they are. The existences of these technological tools have a lot of benefits, ranging from as a nice if they are used by the students to learn, not just on social networks such as Facebook, and another beneficial learning environment like the Learning Management System (LMS) such as Blackboard or WebCT. LMS are computer technology. Because through a computer program (internet), the users allows to save, organize and manipulate information, including text data and numerics (Eggen & Varenhorst, 2007, p. 430). E-learning is a great model to deliver the course, because the students can work together in solving the problem. Students are able to communicate their ideas and dare to be interact with each other in processing of problem solving. In the activities, students are trained to be creative and caring in problems solving, both social and environmental interact with each other in processing of problem solving.

The results of implementation show that the learning of mathematics through VirtualMATRIKS showed the good comprehension) with the average of learning result is 80,57.

Based on the conclusions of this study, it can be suggested that this model can be applied and developed further in Senior High School, and this model could be tested in mathematics courses that meet the valid, practical and effective criterias.

B. Method

1) Problem formulation

The problems that formulation as the development of RME-based blog was effective in improving students' understanding. The students are almost never given the opportunity by the lecturers example given by lecturers. The students are almost never given the opportunity by the lecturers. Therefore, this study give the opportunity to the students to learn together in a group. From the tests that were done through pre-test and post-test, through learning, to identify basic ability, to write performance objectives, develop methods from time to time. Lecturers need to select and use models, approaches, methods, or other kinds of learning research. The blog in the delivery of learning is an effective method in motivating students, the students can interact with one another, can help to understand the material more easily, so that if the lecturers can provide a good message, the students will write comments and opinions on the blog. In this case, the use of the blog will be more effective. In the delivery of learning, to identify basic ability, to write performance objectives, develop methods from time to time. Lecturers need to select and use models, approaches, methods, or other kinds of learning research. The blog in the delivery of learning is an effective method in motivating students, the students can interact with one another, can help to understand the material more easily, so that if the lecturers can provide a good message, the students will write comments and opinions on the blog. In this case, the use of the blog will be more effective.

Questionable quality of this article

Upon the conclusions of this study, it can be suggested that this model can be applied and developed further in Senior High School, and this model gives a positive impact on student learning outcomes (cognitive, affective, and senior high school is an institution that serves students who want to complete their studies, not just on social networks such as Facebook, and another beneficial learning environment like the Learning Management System (LMS) such as Blackboard or WebCT. LMS are computer technology. Because through a computer program (internet), the users allows to save, organize and manipulate information, including text data and numerics (Eggen & Varenhorst, 2007, p. 430). E-learning is a great model to deliver the course, because the students can work together in solving the problem. Students are able to communicate their ideas and dare to be interact with each other in processing of problem solving. In the activities, students are trained to be creative and caring in problems solving, both social and environmental interact with each other in processing of problem solving. In the activities, students are trained to be creative and caring in problems solving, both social and environmental interact with each other in processing of problem solving. In the activities, students are trained to be creative and caring in problems solving, both social and environmental interact with each other in processing of problem solving.
...the question of whether and how technology can and enrich visualisation, while also laying a foundation for deductive proof.1234 Australasian Journal of Educational Technology, 2012, 28(7) technology in teaching and learning”. From these different arguments it is clear that considerable uncertainty within the educational community regarding the value of technology, there is limited evidence of positive effects on student achievement.

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In 1987. In fact, Myhre, Popejoy and Carney (2006, p. 1002) pointed out that there is also better student achievement (Cuban, 2001). According to Brown-L’Bahy (2005), activities and problems. The difference between the groups was that dynamic explorations by the dragging of points, vertices and objects:

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Dynamic geometry has the potential to increase access and exposure to quality information, and 5) combining creative thinking, intuitive and associational thinking, 3) can encourage analogical thinking, 4)

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other advantages of developing blogs with RME based are as follows: 1) the student without any pressure. Learning without the pressure will be more meaningful. 2) can ask for the help of people who preferred to give understanding to those who are less understand. Huette (2006) also described the benefits of using blogs in the classroom, among other things: 1) to promote critical thinking and analytical, 2) to encourage solitary and social interaction.

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One thing that allows everyone to access. Huette (2006) also described the benefits of using blogs in the classroom, among other things: 1) to promote critical thinking and analytical, 2) to encourage solitary and social interaction. In order to investigate this, a quasi-experimental non-equivalent group design was used. The study was conducted in the form of small group evaluations. The results were obtained from the questionnaire in the form of descriptive percent. Formative evaluations are conducted with the mechanism of one to one evaluation, while the post-test was given after they understood the blog with the problem-based learning. Based on the research results, discussion and conclusions can be recommended: 1) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators who can ask for the help of people who preferred to give understanding to those who are less understand. 2) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. The study found that the use of dynamic geometry software allows students to develop and reinforce concepts, to rectify common errors, to check graphical solutions, and to enhance the desire to learn. A study by Usun (2007) suggested that technology in teaching and learning can the potential to increase access and exposure to quality information, and 5) combining creative thinking, intuitive and associational thinking, 3) can encourage analogical thinking, 4) can ask for the help of people who preferred to give understanding to those who are less understand. The difference between the groups was that dynamic explorations by the dragging of points, vertices and objects:

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Based on the research results, discussion and conclusions can be recommended: 1) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. Therefore, the results of the data analysis and discussion above can be shown that the use of dynamic geometry software allows students to develop and reinforce concepts, to rectify common errors, to check graphical solutions, and to enhance the desire to learn. 2) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. 3) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. 4) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. 5) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. The study found that the use of dynamic geometry software allows students to develop and reinforce concepts, to rectify common errors, to check graphical solutions, and to enhance the desire to learn. 2) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. 3) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. 4) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators. 5) the research can be carried out by quasi-experiments involving the appropriate with learning system as learning needs in the classroom, in addition to the educators.

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Once a construction is completed, the user can drag certain elements of it, and
the changes made are immediately reflected in the drawing. The software
also allows for the saving of constructions for future use, and these saved
constructions can be imported into other applications. The software
provides a wide range of geometric figures, including shapes such as
triangles, circles, and polygons, and allows users to
perform operations such as drawing, measuring, and
manipulating objects. It includes a variety of tools for
drawing and measuring, such as rulers, protractors,
and compasses. The software also includes a large
data base of geometric figures and theorems, which
users can access and use in their constructions.

The current research study is the first to examine the impact of dynamic
gallery software on student performance in geometry. The
researchers investigated whether the use of dynamic
gallery software, such as GeoGebra, can improve
student understanding of geometric concepts and
improve their problem-solving skills in geometry.

The main goal of the research study was to determine
whether the use of dynamic gallery software can
improve student performance in geometry. The
researchers conducted a study among Form 3 students in one of the
secondary schools in Malaysia and found that the use of dynamic
gallery software can significantly improve student
performance in geometry.

The results of the study suggest that the pre-service mathematics
teachers did not have a deep understanding of geometry. It
becomes evident that teaching geometry at the secondary school
level is an important aspect of education, and it is necessary
to develop effective strategies to improve teaching
and learning in this area.

The current research aims to investigate whether and how the use of
dynamic gallery software influences the specific Van Hiele
levels. The researchers used a pretest-posttest design
and analyzed the data using statistical methods.

Table 1: Non-equivalent comparison group design

<table>
<thead>
<tr>
<th>Student</th>
<th>Pre-test</th>
<th>Treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>21</td>
<td>34</td>
<td>35</td>
</tr>
<tr>
<td>Group 2</td>
<td>22</td>
<td>36</td>
<td>37</td>
</tr>
</tbody>
</table>

The researchers also used the Cognitive Development and Achievement
Instrument (CDASSG Van Hiele Geometry Test) that forms part of the
measurement. By using the Kuder-Richardson Formula 20 in his study
(1982), he found that the pre-test reliability of this
measure was 0.72. The researchers conducted the study among Form 3
students in one of the secondary schools in Malaysia and found
that the use of dynamic gallery software can significantly improve
student performance in geometry.
The study sought to use the Van Hiele theory to investigate the geometric cognitive development of students in a technology-enriched environment. This study applied (see Table 2).

The means were computed to summarise the scores (out of 5) for each Van Hiele level. A few students selected distracters A and C, distracters D and E attracted quite a number of students. A possible reason for selecting options D and E could be that a few students were under the impression that the inclusion property works in two directions. Students found it difficult to grasp the idea of class inclusion as a hierarchical classification, such as a rectangle being a type of a parallelogram. The idea of class inclusion would appear confusing for some students. Question 4 was included in the post-test to evaluate the conceptual understanding of individual questionnaire items, a McNemar test was applied (see Table 2). The majority of students did not reach the basic definitions and properties of the different quadrilaterals. Question 4 was about the selection of quadrilaterals as a type of a parallelogram. The idea of class inclusion was used in F-geometry. The concept of an axiomatic system is a basic definition in F-geometry. In F-geometry, which is different from the geometry of Euclidean, the concept of a parallelogram is not required. In F-geometry, the concept of a parallelogram is not required. In F-geometry, the concept of a parallelogram is not required. In F-geometry, the concept of a parallelogram is not required.
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...
Therefore, the present study investigated the effects of split attention (i.e. visual search) and mental integration that were required in order to solve the given tasks. In line with cognitive load theory, split attention induced split cognitive load, where less capacity was available to solve the main task, whereas mental integration imposed a heavy mental load that prevented the problem solver from focusing on the task at hand. It should be noted though, that these beneficial effects may be explained by the classical view (e.g. Clement, 1985) where it is assumed that the availability of worked examples as an analogy for problem solving, will lead to improved learning and transfer (i.e. higher test performance), a heavier reliance on worked example study rather than on problem solving (e.g. Cooper & Sweller, 1987; Goos, 1999), arguing that this would be more motivating for students (e.g. Cooper & Sweller, 1987; Van Gog et al., 2006, 2008), whereas others have used example-problem pairs, consisting of problem solving (e.g. Van Gerven, Paas, Van Merrieënboer, & Schmidt, 2006) as well as during the test (i.e. lower) (see e.g. Paas, 1992; Paas & Van Gog, 2003). The results showed no significant differences in learning as shown by higher test performance. Moreover, this beneficial effect was also observed for more knowledgeable learners. With extended practice, certain worked examples become more understandable in the mind of a learner, and only when the examples are well-designed. To start with the latter, the availability of worked examples as an analogy for problem solving is a common technique in education, particularly in primary education (e.g. Sweller & Paas, 1999). Thus, in order to elucidate the positive effects of worked examples on transfer, a study has been conducted that investigated the effects of split attention (i.e. visual search) and mental integration (i.e. problem solving) on transfer (i.e. test performance) in a worked example context.

In sum, the worked example e-learning system in the primary mathematics classroom is an effective, efficient, and easy-to-use instructional method that can be applied in the classroom. The system allows teachers and learners to interact with each other and to receive immediate feedback on their performance. The system can be used to provide learners with a variety of worked examples, which can be used to help them understand the concepts and procedures associated with primary mathematics. The system can also be used to assess learners' understanding of the material and to provide them with additional practice. Furthermore, the system can be used to provide learners with self-paced instruction, which can be adapted to their individual needs and learning styles. The system is an excellent tool for teachers who are looking for an effective, efficient, and easy-to-use instructional method that can help their learners to achieve success in primary mathematics. In conclusion, the present study has demonstrated the positive effects of working example study on transfer (i.e. test performance), a heavy reliance on worked example study rather than on problem solving, which can be explained by the classical view (e.g. Clement, 1985) where it is assumed that the availability of worked examples as an analogy for problem solving, will lead to improved learning and transfer (i.e. higher test performance), a heavier reliance on worked example study rather than on problem solving (e.g. Cooper & Sweller, 1987; Goos, 1999), arguing that this would be more motivating for students (e.g. Cooper & Sweller, 1987; Van Gog et al., 2006, 2008), whereas others have used example-problem pairs, consisting of problem solving (e.g. Van Gerven, Paas, Van Merrieënboer, & Schmidt, 2006) as well as during the test (i.e. lower) (see e.g. Paas, 1992; Paas & Van Gog, 2003). The results showed no significant differences in learning as shown by higher test performance. Moreover, this beneficial effect was also observed for more knowledgeable learners. With extended practice, certain worked examples become more understandable in the mind of a learner, and only when the examples are well-designed. To start with the latter, the availability of worked examples as an analogy for problem solving is a common technique in education, particularly in primary education (e.g. Sweller & Paas, 1999). Thus, in order to elucidate the positive effects of worked examples on transfer, a study has been conducted that investigated the effects of split attention (i.e. visual search) and mental integration (i.e. problem solving) on transfer (i.e. test performance) in a worked example context.

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The current study aimed to investigate the effectiveness of worked examples in teaching subtraction with borrowing in Dutch elementary school classes. Specifically, it examined whether the availability of worked examples influenced student performance, cognitive load, and student engagement during the learning process.

Procedure

The study was conducted over a 3-week period. At the beginning of the 3-week period, participants first completed the pretest, indicating their baseline performance. Students in the experimental group completed six lessons on subtraction with borrowing, with an additional worked example being provided for each lesson.

The control group engaged in their regular instruction and self-study using the "RekenRijk" method (Bokhove et al., 2003). This method consists of 12 blocks per year. This specific study used the "Blocks of 10" and "Blocks of 100" blocks for teaching subtraction.

Posttest and posttest and for each lesson according to a digital alarm clock that was placed in the classroom, and at the end of each lesson rated their perceived cognitive load.

Results

An ANOVA showed that in contrast to our hypothesis, perceived cognitive load usually consists of solving problems by oneself without any additional instruction or support. The results indicated that the experimental group showed a significant reduction in the amount of perceived cognitive load from pretest (M = 2.70, SD = 1.03) to posttest (M = 1.62, SD = 0.87), F(1,42) = 101.94, MSE = 21.89, p < .001; however, there was no significant difference in performance between the experimental and control groups.

Discussion

The results suggest that the availability of worked examples can positively influence student performance and reduce perceived cognitive load during the learning process. This supports the instructional principle from the worked examples research that worked-out examples can facilitate learning by providing a clear example of how to solve a problem, thus reducing cognitive load and increasing understanding.

It is interesting to note that students in the experimental group experienced a significant reduction in perceived cognitive load from pretest to posttest, whereas the control group showed no significant difference. This supports the idea that worked examples can help students manage their cognitive load by breaking down complex tasks into more manageable steps.

References


André Heck

How a Realistic Mathematics Education Approach and ICT-Supported Teaching and Learning Activities Fosters Indonesian Pupils’ Thinking and Understanding

A systematic literature review relating to the use of ICT in Indonesian mathematical education

The authors decided to design and test ICT-supported teaching and learning activities that foster pupils’ thinking and understanding in the reformed setting. The results of the classroom process for pupils of coming to grips with mathematics.

Mathematics Education (RME) approach in an Indonesian classroom context. The topic chosen concerns some characteristics of the RME approach and used a Microcomputer-Based Learning Environment (MBL) application.

The authors expected the following to occur during the research project:

(a) Concerning MBL: It enables pupils themselves to construct and interpret graphs that are related to real situations, and this helps to correct their alternative conceptions in graphing.

(b) Concerning RME: The topic kinematics is appropriate for the RME approach, as it can be perceived as a highly contextualized and situated activity. Pupils can discover basic kinematic concepts in the process of solving everyday problems, such as the motion of a bicycle, a car, or a train. Moreover, the notion of distance and time is familiar to pupils because they are always present in their daily lives. This makes it easy for pupils to relate the learning material to their real-world experiences.

Possibilities for interview with teachers

The authors wanted to find answers to the following questions about the MBL approach:

- Does it lead to achievement gains?
- How positive are pupils’ opinions about the MBL approach?
- Does the MBL approach lead to transfer of learning?


Appendices

1. Constraints of the study might become a model for later use by teachers. Results of the study might also reveal experiences and opinions of the pupils and the teacher with respect to the activities and performances in this subject is generally still poor: for instance, Indonesian 8 th grade pupils used the specially designed materials and activities. This included the use of interactive learning environments (ILE), which are computer-based learning tools that allow for interactive and dynamic interactions between learners and the learning content.

2. Possible real-life examples of teaching and learning mathematics in Indonesia. This includes examples from the authors’ own teaching experiences, as well as examples from other Indonesian teachers. The authors hope that these examples will provide insight into how RME can be implemented in an Indonesian classroom context.

3. The research team decided to design and test ICT-supported teaching and learning activities that foster pupils’ thinking and understanding in the reformed setting. The results of the classroom process for pupils of coming to grips with mathematics.

4. The study will be conducted in an Indonesian Junior High School (SMP). The school is located in the city of Bandung, West Java, Indonesia. The school has 1,200 students, with 60 students in each class. The school’s mathematics department is equipped with 2 computer rooms, each containing 30 desktop computers.

5. The research team will collaborate with the mathematics department of the school to design and test the ICT-supported teaching and learning activities. The team will be responsible for the implementation and evaluation of the activities. The results of the study will be shared with the mathematics department, to inform future teaching and learning practices.

Downloaded by [North West University] at 00:46 28 May 2015

References

Bartolini Bischi, Guido, 


assigning them to the slope. An example of such an error is the use of graphical feature of
microcomputer-based laboratory in mathematics and science education.

Weintraub (as cited in McKenzie & Padilla, 1986) stated, "Graphs present concepts in a concise
philosophy of realistic mathematics education, and the theory and practice of the use of

The research background of this study consists of three elements: results of research on graphing,

• Iconic interpretation ('graph as a picture' error). Pupils sometimes interpret a graph of a

graphs of these variables should be identical; they appear to readily switch labels on axes

• Interval/point confusion. In interpreting graphs, pupils often narrow their focus to a single

judging, agreeing and disagreeing, questioning alternatives, and reflecting.

• Use of pupils' contributions. Pupils should have the opportunity to produce more concrete

• Use of models or bridging by vertical instruments. In solving problems, pupils develop and

process. On the contrary, the phenomena in which the concepts appear in reality can be taken

use of pupils' contributions. Pupils should have the opportunity to produce more concrete

• Use of vertical mathematics. Pupils should develop an understanding of mathematics as a

The mechanistic approach is based on drill practice. Mathematics is seen as a system of rules

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rational approach. The important thing is to check if an approach is appropriate or not. The

tables. This process makes it easier for pupils to understand the concepts and rules of

The mechanistic approach is based on drill practice. Mathematics is seen as a system of rules

• controlling apparatus (e.g., a lamp or a motor);

data analyses are often considered as a part of MBL.

• collecting position-time data from moving objects in digital video clips or in a sequence

data;
Pupils would conclude their practical work with a short investigation task that they could
1. How far from the detector should you start?

Steps of Practical Work 3:
4. Walk the graph (continued) or explain why the given graph cannot be a motion graph. Skills:
   5, 6, 7, 8, 9, 12, 14.
3. Walk the graph, i.e., simulate a motion that produces (as similar as possible) some given
   graphs to be matched beforehand.
Teacher's Guide and a Pupils' Guide. The section in the Pupils' Guide for Practical Work 3 is
Pupils would be asked to prepare a presentation of their results for the final classroom
5. When (in which time interval) do you walk at highest speed?

6. Determine the velocity in each time interval (0 to 3, 3 to 6, 6 to 9, 9 to 13, 13 to 18)

Have a look on the v-t graph. Compare the result with your answer to question 6.
13. knowing that in reality time cannot move backward to zero and that actions do not happen
10. timing a graph remains a given graph, in particular, making the connection between a
9. finding a speed graph to be matched graphs and pupils to identify the mentioned
8. finding a speed graph to be matched graphs and pupils to identify the mentioned
7. knowing the meaning of zero slope;
6. knowing that in reality time cannot move backward to zero and that actions do not happen
5. point reading and the meaning of coordinates;
4. knowing what is meant by the term "velocity" in the context of speed and direction;
3. knowing that in reality time cannot move backward to zero and that actions do not happen
2. knowing that in reality time cannot move backward to zero and that actions do not happen
1. knowing that in reality time cannot move backward to zero and that actions do not happen

While the given activities were chosen because of the instructional value of the relationship
and a useful mathematical tool;
• global understanding of a graph and connecting it to the situational context, i.e., seeing a
• describing a given graph in simple words, e.g., using a graph for communication purposes;
• all tasks in the section on graph reading are translations of interpretation type and
• all tasks in the section on graph reading are translations of interpretation type and
• global), its character (quantitative or qualitative), and its focus (e.g., point reading, interval
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Figure 1. Set up of the computer laboratory (dimension: 9m × 8m). The rectangles represent
computers (Coach 5 was installed in the shadowed ones) and the dashed lines represent the
surrounding tables and computers.
His reason was: Distance

Stefanus assigned option B for Valentina's graph (graph on the left).

Below is a distance – time graph of a trip.

... from a distance-time graph (it was just implicitly done in some of the practical works).

Wrong, because in this graph, it's back to initial place three times with constant velocity.

I take the train every day to go to school. On the way, the train stops twice.

In question 5 in the pre-test, pupils were given a description of trips done by three people

Olivia's answers for option A and B were:

Some options of graphs were given and pupils were asked to answer and give their reason

The diagram should be transformed into a velocity-time graph (see related question from the post-test in Figure 3) was shown by

A ball was rolled by somebody on a flat surface. It moved along the surface, went up a small bump and

The teacher asked unrelated questions, and unfocused discussion followed as a result. In spite of

As an assessment, the groups would do their presentation of the 6th task in pairs instead

Pupils: performance

Post-experiment: pupils described graphs on the post-test. Table 1 shows the final exam result. In terms of the scores, objectives in the unit seem to have been met more generally than in the pre-test. In the post-test, pupils showed a general understanding of the concepts.

Pupil: performance

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...indications that low achievement pupils might benefit more than high achievement pupils (see the during all practical works. This and also the changes to some parts of the lesson design caused of comparative data. One experiment in one class is a weak basis for making generalized of proving their hypotheses. We would like to state that one of the most important changes in the sophisticated facilities. Pupils' and teachers' familiarity with technology is also not something pay more attention in the learning materials to understanding velocity-time graphs and to In further research concerning RME-based materials and also in the implementation of an The problem of lack of space in the computer lab forced the teacher and us to split the class One of the limitations in the research experiment was the size of observational data and the lack need the support and openness of both policymakers and school management. Provision of...tions. It should be noted that this last comment was tentative. If there environment. They are also trained in doing presentations, speaking in front of an audience, and Moreover, pupils become acquainted with new technology, which is an advantage for them. According to the teacher, the chosen approach offers both parties (teacher and pupils) in the sense that he liked his new role and would like to have more teaching and learning activities help pupils to relate what they had learned to problems in daily life? However, by using...activities help pupils to relate what they had learned to problems in daily life? However, by using...option B: Wrong, because in the beginning, the vehicle was not moving in a velocity of...Which of the four graphs below most likely represents the velocity - time graph of the trip? Explain your reason!
Memos (0)

Student rectangles. Students in both groups were pre-tested and post-tested for their geometry performance for rectangles. The community which in turn has felt the need to evolve in its (ICT) have awakened the interest of the educational use of computers. There were 121 students in the control group, of 113 students, who were taught of rectangles by the support thinking in school [7], [8], [9].

Our research experiment leads us to the following list of recommendations for teachers who want to implement RME-based and ICT-supported lessons:

**Recommendation for Teachers**

- **Organizational things should be paid much attention.** It is always better to make sure far.
- **Especially from the implementation of our instructional unit, we can learn that it is useful to**
- **valuable to them.**
- **The use of ICT rectangles.pdf**
- **students encounter later are connected with insufficient**
- **hinder the process, but too many activities might result in bored and exhausted pupils.**
- **practice, training, and customization of teachers' behavior.**
- **especially from the implementation of our instructional unit, we can learn that it is useful to**
- **encourage pupils**
- **transfer, and training of new teachers.**
- **to implement RME-based and ICT-supported lessons:**
- **In general, teachers must be willing to change their role in the classroom towards more**
- **planning, training, and customization of teachers' behavior.**
- **to adjust to the pupils' more active role in learning. We suppose that encouraging pupils**
- **We suppose that encouraging pupils**
- **preparation of teachers for realistic mathematics education. Educational Studies in Mathematics, 32, 1–28.**
- **Svec, M.T. (1999). Improving graphing interpretation skills and understanding of motion using**
- **microcomputer-based laboratories. Electronic Journal of Science Education, 3(4). Available:**
the critical value of the t ratio (t = -2.743) was 0.007. Therefore, equality of variances was not significant (F = 2.594, p = 0.104). The dependent variable was the student's post-PST score. Levene's Test for equality of variances was not significant (F = 2.594, p = 0.104). The t-test for equality of means was used to compare the post-PST scores of the experimental and control groups. The mean grade for the pre-test in the study was 0.785, and for the post-test it was 0.821. Analysis of the data was carried out using the SPSS (version 19) software which was designed using Flash CS3 Professional.

In the first phase of the PSM, the children were taught to distinguish between pre and post-PST scores. The mean grade for the pre-test in the study was 0.785, and for the post-test it was 0.821. Analysis of the data was carried out using the SPSS (version 19) software which was designed using Flash CS3 Professional.

In the second phase of the PSM, the children were taught to formulate their own problem situations. The dependent variable was the use of educational software. The main purpose of the software is to foster the first level of the PSM, which is to represent objects and fitting together several figures under certain conditions. Examples of such operations could be 'Which shape is a square?' or 'Which shape is a rectangle?'. These questions are often used in the Van Hiele theory, which is one of the basic axes of geometric thought as it develops through several levels of geometric competences.

In the third level, students should be able to analyze their environment and identify different objects based on their properties. The question 'Which shape has four sides' is an example of such a question. At the third level, young students were introduced to visual recognition, spatial sense, and the ability to recognize different shapes and their properties.

In the fourth level, students should be able to face direct problem situations. At this level, the students are asked to formulate their own problem situations and to choose the correct shape among triangles, circles, squares, and rectangles. Examples of such activities could be as follows: 'Draw a rectangle.', 'Bring me something that is a rectangle from the classroom.' or 'Which shape has four sides'. The students were also implicated with problem situations in which they had to recognize the shapes from their properties and directions are given to the user through a recorded message. For example, once an activity is selected, the problem is announced and directions are given to the user through a recorded message. Regarding the educational software represented above, the software has been designed for this research was inspired by the framework of RME, a group of Dutch mathematics education researchers, and can be beneficial on promoting self-regulated learning. The dependent variable was the use of the software.

The PST was used by 231 students. One hundred and eleven of the students were male and 120 were female. There were two groups in the study, one control and one experimental. Five schools were involved in the study, four were experimental and one was control. In the control group, there was one computer in the class and a teacher. In the experimental group (n=113), in the control group there was not a computer available for the students' use, while in the experimental there was one computer in the class and a teacher. The research was carried out during the 2012-2013 school year in the public primary schools located in the city of Athens, Greece. The students involved were 231 third graders (113 boys and 118 girls). Separate groups for the experimental and control groups were formed in the study. The mean grade for the experimental group was 0.795, and for the control group it was 0.778. The mean grade for the pre-test in the study was 0.785, and for the post-test it was 0.821. Analysis of the data was carried out using the SPSS (version 19) software which was designed using Flash CS3 Professional.

In the first level of the PSM, the students were taught to recognize geometric shapes. The question 'Which shape is a square?' or 'Which shape is a rectangle?' is an example of such a question. At the first level, the students were taught to recognize shapes and to identify their properties. Examples of such activities could be as follows: 'Draw a rectangle.' or 'Bring me something that is a rectangle from the classroom.' The students were also implicated with problem situations in which they had to recognize the shapes from their properties and directions are given to the user through a recorded message. For example, once an activity is selected, the problem is announced and directions are given to the user through a recorded message. Regarding the educational software represented above, the software has been designed for this research was inspired by the framework of RME, a group of Dutch mathematics education researchers, and can be beneficial on promoting self-regulated learning. The dependent variable was the use of the software.
The purpose of the study was to investigate the impact of the use of ICT in preschool education for the teaching of mathematics. The study included a control group and an experimental group. The control group was taught using traditional methods, while the experimental group was taught using ICT tools.

The results of the study showed that the students in the experimental group performed better on the post-test than the students in the control group. The statistical analysis supported our initial hypothesis, considering the observed differences in performance between the two groups.

**TABLE I. GROUP STATISTICS OF PRE TEST**

<table>
<thead>
<tr>
<th>Group</th>
<th>Ν</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>35</td>
<td>0.37013</td>
<td>4.19917</td>
<td>0.38174</td>
</tr>
<tr>
<td>Experimental</td>
<td>35</td>
<td>35.0354</td>
<td>121</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE II. INDEPENDENT SAMPLES TEST OF PRE TEST**

<table>
<thead>
<tr>
<th>Pair 1 pre-test</th>
<th>Control</th>
<th>Experimental</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.38174</td>
<td>0.37013</td>
<td>0.38174</td>
<td>35.0354</td>
<td>121</td>
<td>0.38174</td>
</tr>
</tbody>
</table>

**TABLE III. PAIRED SAMPLES STATISTICS OF PRE AND POST TESTS**

<table>
<thead>
<tr>
<th>Pair 1 pre-test</th>
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<th>t</th>
<th>df</th>
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**TABLE IV. PAIRED SAMPLES TEST OF PRE AND POST TESTS**

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<td>121</td>
<td>0.38174</td>
</tr>
</tbody>
</table>

**TABLE V. GROUP STATISTICS OF POST TEST**

<table>
<thead>
<tr>
<th>Group</th>
<th>Ν</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
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<td>0.43904</td>
<td>4.66708</td>
<td>0.38610</td>
</tr>
<tr>
<td>Experimental</td>
<td>35</td>
<td>3.95110</td>
<td>38.3451</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE VI. PAIRED SAMPLES TEST OF PRE AND POST TESTS**

<table>
<thead>
<tr>
<th>Pair 1 pre-test</th>
<th>Control</th>
<th>Experimental</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.38174</td>
<td>0.37013</td>
<td>0.38174</td>
<td>35.0354</td>
<td>121</td>
<td>0.38174</td>
</tr>
</tbody>
</table>

**TABLE VII. GROUP STATISTICS OF POST TEST**

<table>
<thead>
<tr>
<th>Group</th>
<th>Ν</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>35</td>
<td>0.43904</td>
<td>4.66708</td>
<td>0.38610</td>
</tr>
<tr>
<td>Experimental</td>
<td>35</td>
<td>3.95110</td>
<td>38.3451</td>
<td></td>
</tr>
</tbody>
</table>

The results of our research show that teaching and learning through ICT is an interactive process for the first graders. The results indicate that students of the experimental group as opposed to those in the control group, displayed a greater improvement on the post-test. The effective use of ICT in the classroom can improve student engagement and motivation. Further research is needed to explore the effectiveness of different ICT tools and strategies in the teaching of mathematics.
The purpose of this study is to investigate the use of information and communication technologies (ICT) in first grade primary school. The study, based on the Realistic Mathematics Education (RME) theory, examines the effects of a new model based on ICT on geometry teaching. This theory was developed by Nathan and Schifter, as an extension of van Hiele's levels of thinking. Following this principle, the software designed and the students' learning can significantly help in developing proper mathematical understanding. Following the theoretical framework that blends together Realistic Mathematics Education (RME) with the use of ICT, the study was conducted in three phases. In the first phase, the students were taught using the Primary Shape Model (FCPSM) which consisted of five levels. In the second phase, the control group taught with traditional methods, while the experimental group were taught using both traditional and ICT methods. In the third phase, both groups were taught using ICT methods. The results indicated that teaching and learning through ICT is an important outcome of this study. It was designed following the background of RME theory and the majority of previous studies have aggregatedly examined the effects of various teaching on the geometric shapes. However, a small number of studies investigated the differences regarding the effects of teaching circles, triangles, rectangles, and squares separately. In addition, based on the previous studies, we set out to examine the following hypotheses:

1. The students who will be taught squares with intervention based on FCPSM will have a significant improvement in comparison to those taught using the traditional teaching method according to the first grade curriculum.

2. The students who will teach the shape of triangles with intervention based on FCPSM will have a significant improvement in comparison to those taught using the traditional teaching method according to the first grade curriculum.

3. Is it true that the children aged 15 to 25 years will have an improvement in comparison to those taught using the traditional teaching method according to the first grade curriculum?

4. The students who will teach the shape of rectangles with intervention based on FCPSM will have a significant improvement in comparison to those taught using the traditional teaching method according to the first grade curriculum.

5. The students who will teach the shape of circles with intervention based on FCPSM will have a significant improvement in comparison to those taught using the traditional teaching method according to the first grade curriculum.

The present research was conducted in three phases. In the first phase, geometry was introduced to the students using a realistic context. In this level, a story was presented with the video projector in the classroom. In this story, the grandparents of the problem as underlined by the RME theory. In the whole trajectory of the RME teaching theory, five main focuses of the learning and teaching procedure concerning primary education.

1. (a) introducing a problem using a realistic context; (b) identifying an object of the problem as underlined by the RME theory; (c) making a conjecture about the shape of the problem; (d) encouraging the process of reinvention with the appropriate educational scenarios; (e) evaluating the obtained results.

In addition, based on the previous studies, we set out to answer the following question: Are there any differences between the students taught in the experimental or control groups? The results of this study can be used to support the development of efficient and effective curriculum for primary education. It can also be used as a tool for the students to become more familiar with the shape of the different objects of the problem. The results of this study can also be used to support the development of efficient and effective curriculum for primary education.
The van Hiele model uses five levels, however, for the first grade students, the geometric thought as it develops through several levels of sophistication under the influence of a school curriculum [41].

The research by Clements et al. [40] based on the second van Hiele model stated the need to focus on basic shapes, a rhombus as a figure with four equal sides [42].

The third level of the teaching procedure included activities using plasticine (fourth level).

In the fourth level of the teaching procedure, according to the research by Clements et al. [40], prior research in the mathematics intervention on first grade students' geometry 

Due to the young age of the students, the pre-tests were presented to them by the teacher. These were pencil-and-paper tasks in which the students were asked to name the shapes and their properties of angles. The students are separated into groups and cooperated with one another to make a shape with their bodies on the floor. Then, they were separated into groups and cooperated with one another to make a shape with their bodies on the floor. Then, they were separated into groups and cooperated with one another to make a shape with their bodies on the floor.

The children were separated into groups and cooperated with one another to make a shape with their bodies on the floor. Then, they were separated into groups and cooperated with one another to make a shape with their bodies on the floor. Then, they were separated into groups and cooperated with one another to make a shape with their bodies on the floor. Then, they were separated into groups and cooperated with one another to make a shape with their bodies on the floor.

Figure 4. Each student was instructed to make fake cookies from plasticine (fourth level).

The descriptive statistics for students' scores for circles and triangles are presented in Table 1. The results of the ANCOVA analysis showed that the group (experimental group vs. control group) had a statistically significant main effect on the students' scores for circles (F(1, 231) = 44.384, p < .001, η^2 = .161). After adjusting for FCPST scores for circles in the pre-test, the result of Levene's test when pre-test for circles was included in the ANCOVA analysis showed that the assumption of homogeneity of variance was not been violated.

Table 2. Comparison of student scores for circles in post-test:

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>65.41</td>
<td>88.45</td>
<td>23.04</td>
</tr>
<tr>
<td>Control</td>
<td>60.53</td>
<td>74.95</td>
<td>14.42</td>
</tr>
</tbody>
</table>

The descriptive statistics for students' scores for circles and squares are presented in Table 1. The results of the ANCOVA analysis showed that the group (experimental group vs. control group) had a statistically significant main effect on the students' scores for circles (F(1, 231) = 44.384, p < .001, η^2 = .161). After adjusting for FCPST scores for circles in the pre-test, the result of Levene's test when pre-test for circles was included in the ANCOVA analysis showed that the assumption of homogeneity of variance was not been violated.
The outcomes supports that our teaching intervention had a significant effect on the students' FCPST post-test scores (hypothesis 3). Therefore, the third hypothesis was confirmed.

For triangles, the partial eta squared for triangles (η² = 0.224 - Table 3) is higher than it was for rectangles (η² = 0.201 - Table 4). Also, the partial eta squared for circles (η² = 0.161 - Table 2) is higher than it was for squares (η² = 0.193 - Table 5). Finally, the partial eta squared for squares, F(1, 231) = 3.367, p < .001, η² = 0.068 (Table 3); thus the assumption of homogeneity of variance was not been violated.

Then, the analysis of covariance (ANCOVA) showed a statistically significant main effect (covariate), the following results were obtained from the analysis after adjusting for FCPST scores for triangles in the pre-test: squares, F(1, 232) = 5.266, p = 0.003, η² = 0.022; circles, F(1, 232) = 4.148, p = 0.044, η² = 0.017; rectangles, F(1, 232) = 3.367, p < .001, η² = 0.068 (Table 3); thus the assumption of homogeneity of variance was not been violated. The result of Levene's test when performed on the students' post-test scores for squares was performed to evaluate the effect of the intervention. The result of Levene's test when performed on the students' post-test scores for squares was performed to evaluate the effect of the intervention.
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Hermeneutic Unit: Systematic literature review relating to the use if IC...

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23 quotations
Memos (0)
%role players, &&learning environment, @@value of using ICT, @Devices

conceptual framework for purposeful learning activity.

Teachers' knowing how to use technology: exploring a

Software Programs: An Observation of Capabilities and


10.1080/13598660601111307.

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Behavior, 28, 30–40.


for Research on Mathematics Teaching and Learning, 420- 464,

spatial reasoning, In D. A. Grouws (Ed.), Handbook of

Development of Young Children's Mathematical Thinking:


technologies for teaching and learning: Challenges for higher


learning: embedding ICT into everyday classroom pra ctices.


academic achievement of young African American chil dren.

Research in Mathematics Education, 30(2), 192-212

Geometry Teaching Through ICT

Sutherland et al., 2004 ). They are used as a tool for the students to become more

applications embedded in appropriate educational sc enarios (Dwyer, 2007 ; Fisher,

in all sectors and subjects if supported by developmentally appropriate software

applications. In the most ideal setting, information communication technologies are treated as a

as if they are a "human activity." According to his perspective, in order for mathematics to be

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as a "human activity." According to his perspective, in order for mathematics to be

as a "human activity." According to his perspective, in order for mathematics to be
two groups in the study, one control (n = 121) and one experimental (n = 113). In the control group there was not a computer available for the students’ use. The classes at schools located in the cities of Rethymno in Crete (two classes) and Athens (eight classes) were compared. It was an experimental research which compared the FCPSM teaching on the geometric shapes. However, a small number of students had access to computers in some schools of the experimental group. In the experimental group, a group of five students was assigned to the computer-based teaching, whereas another group of five students had access only to printed material. In this study, 75 students were assigned to the ICT-based teaching procedures, whereas 76 students were assigned to the traditional teaching method according to the first grade curriculum. The students’ ages ranged from 40 to 50-year-olds with in-service teaching experience ranging from 15 to 25 years.

The first phase of the teaching intervention involved the teaching of the case of circles, only the thickness and size may be varied. Rectangles and triangles may also share differences in characteristics of thickness and size with the addition of other variable characteristics such as in height and width. Furthermore, a number of research studies have been conducted with the aim of investigating the effect of various teaching interventions on each shape distinctly. Specifically, in the experimental group we used the concept of geometric shapes, we examined the impacts of using ICT in primary schools. To this end, we designed a new model referred to as Geometry Teaching Through ICT in Primary School. We applied this model in four classes from Rethymno to the control group and the other class to the experimental group.

Methodology

The present study was conducted with the aim of examining the impact of various teaching interventions on each shape distinctly. Specifically, in the experimental group we used the concept of geometric shapes, we examined the impacts of using ICT in primary schools. To this end, we designed a new model referred to as Geometry Teaching Through ICT in Primary School. We applied this model in four classes from Rethymno to the control group and the other class to the experimental group.

1. The students who will be taught circles with educational intervention based on the elementary literature. These studies examined the impact of various teaching interventions on circles. However, a small number of students had access to computers in some schools of the experimental group. In the experimental group, a group of five students was assigned to the computer-based teaching, whereas another group of five students had access only to printed material. In this study, 75 students were assigned to the ICT-based teaching procedures, whereas 76 students were assigned to the traditional teaching method according to the first grade curriculum. The students’ ages ranged from 40 to 50-year-olds with in-service teaching experience ranging from 15 to 25 years.

2. The students who will be taught triangles with educational intervention based on the elementary literature. These studies examined the impact of various teaching interventions on triangles. However, a small number of students had access to computers in some schools of the experimental group. In the experimental group, a group of five students was assigned to the computer-based teaching, whereas another group of five students had access only to printed material. In this study, 75 students were assigned to the ICT-based teaching procedures, whereas 76 students were assigned to the traditional teaching method according to the first grade curriculum. The students’ ages ranged from 40 to 50-year-olds with in-service teaching experience ranging from 15 to 25 years.

The general study on geometric shapes was based on the above hypotheses: We set out to confirm our hypotheses. Our study was based on the above mentioned international literature; we set out to confirm our hypotheses. We aimed to test our hypotheses and explore how the differences in the teaching procedure concerning geometry in primary school.

N. Zaranis

We aimed to test our hypotheses and explore how the differences in the teaching procedure concerning geometry in primary school.

Visual Level, students were able to identify figures such as circles and triangles as visual gestalts. Conceptualization at this level includes being able to name, reproduce geometric objects and analyse the visual properties of objects. The students are able to distinguish between figures through recognition of visual properties. The students are able to distinguish between figures through recognition of visual properties.

Conceptualization at the Visual Gestalt stage implies that students are able to identify and reproduce geometric objects. They are able to distinguish between figures through recognition of visual properties. The students are able to distinguish between figures through recognition of visual properties.

Moreover, the score of the students in triangles was lower than those in circles after receiving the intervention than before receiving it. This indicates that the students were more successful in identifying and reproducing geometric objects as circles than as triangles. The students were more successful in identifying and reproducing geometric objects as circles than as triangles. This is a consequence of the fact that circles are the simplest geometric shapes, whereas triangles are the most complex.

Table 1 Descriptive statistics for students’ standardized scores of experimental and control groups

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circles</td>
<td>0.67</td>
<td>0.65</td>
<td>0.68</td>
<td>0.61</td>
</tr>
<tr>
<td>Triangles</td>
<td>0.63</td>
<td>0.54</td>
<td>0.62</td>
<td>0.55</td>
</tr>
</tbody>
</table>

A set of analyses was conducted to determine the effects of the mathematics intervention on first grade students’ geometry knowledge for circles and triangles. The analyses were conducted using the SPSS (ver. 19) statistical analysis computer program. The independent t-test was performed to examine whether the mean difference in the FCPST posttest scores between the experimental group and the control group was significant. The dependent t-test was performed to test the hypothesis regarding the difference in the mean scores of the posttest between the experimental and control groups.

Analysis 1

The main effect was found for type of intervention on the FCPST posttest scores for circles, F (1, 232) = 4.99, p = 0.026; and for type of intervention on the FCPST posttest scores for triangles, F (1, 232) = 4.85, p = 0.029. The results indicate that the experimental group performed significantly higher in the FCPST posttest for circles than the control group, while the experimental group performed significantly higher in the FCPST posttest for triangles than the control group.

The assumptions of the analyses were tested with the use of normality test, Levene’s test and the homogeneity of variance test. The results of the homogeneity of variance test were as follows: the assumption of homogeneity of variance was not violated, F (1, 232) = 1.12, p = 0.290; thus, the experimental group performed significantly higher in the FCPST posttest for circles than the control group.

The assumption of homogeneity of variance was not violated, F (1, 232) = 1.12, p = 0.290; thus, the experimental group performed significantly higher in the FCPST posttest for circles than the control group.
The study dealt with kindergarten students in Crete, who were divided into two groups (experimental and control). The experimental group consisted of 165 students who were taught geometric shapes through a computer-based teaching model for geometric shapes (Dimakos & Zaranis, 2010; Dissanayake et al., 2007; Gersten et al., 2005; Howie & Walcott, 2009). This outcome supports that, our teaching intervention had a somewhat greater impact in learning triangles than of learning circles for first grade students. Also, the present study demonstrates that our first grade teaching process, through a pre-kindergarten mathematics intervention, is a superior teaching model for geometric shapes in primary school. In this research, we found that it is more difficult for first grade students to learn the geometry of circles and triangles in regard to the geometry competence of the first grade students of primary school. Our findings agree with other similar researches supporting the effective role of ICT in education and more specifically in mathematical teaching through ICT in primary school.

Results of this study expand the research on the effects of appropriate software for teaching geometry. Also, the present study creates a new methodological approach to teaching geometry in primary school. The Hiele model of geometric thinking in primary school.


central group which were not exposed to the experimental approach. Student’s test was used to assess and compare the level of knowledge and skills achieved in the two groups. The analyses of numerical and descriptive statistics were computed. The analysis of variance (ANOVA) was conducted for the pre-test and post-test data to assess the impact of educational intervention on the students’ performance. The means were compared with the Bonferroni correction. The level of significance was set at 0.05. 

### 3.3 Instructional intervention

The feedback users get after following these directions is represented by two different types of information. In the second phase, the teaching intervention was performed.

### 3.2 Participants

In the software represented above, once an activity is selected, a problem is introduced to the student. The feedback users receive after following these directions is represented by two different types of information. The feedback users receive after following these directions is represented by two different types of information. The feedback users receive after following these directions is represented by two different types of information. The feedback users receive after following these directions is represented by two different types of information. The feedback users receive after following these directions is represented by two different types of information.

### 3.1 Research design

In the first and third phases, the students were placed in two groups: the experimental group and the control group. One group was taught with traditional teaching methods, while the other was taught using computer-based educational software. The students from the experimental group were exposed to computer-oriented curriculum, while the control group was not exposed to it. Students in both groups were pre-tested and post-tested for their mathematical achievement. The results showed a significant improvement in the general mathematical achievement of the students in the experimental group compared to the control group.

### 3.4 Results

The study was carried out during the 2012-13 school year in 24 public kindergartens. A growing body of literature provides increasing evidence of the effectiveness of technology in the classroom, parental and student satisfaction with technology, and the convenience of technology have been announced. Although concerns about developmental problems related to the过度使用 of computer technologies to facilitate instruction and learning across a variety of educational settings have been raised, many studies have determined that technology has had positive influences on children's cognitive and sensory developments.
The Table 6 shows that 26.06% of the students of the experimental group exhibited in the counting portion of TEMA-3 was divided into three equal categories: less than 7 post-test scores for counting, $F(1, 332)=8.882, p=.003, \eta^2$. A two-way ANOVA was conducted that examined the effect of class (experimental is presented including both groups (i.e. the experimental and the control group) before general mathematical achievement score.

The first analysis was a paired t-test among the students' TEMA-3 pre-test scores of general mathematical achievement to evaluate the effectiveness of the intervention (Table 4, Fig. 8). Also, the effect of group was also significant ($F(1, 329)=59.678, p=.002, \eta^2$), with children in the experimental group scoring higher in the TEMA-3 post-test for addition than the control group. The results of the analysis of covariance (ANCOVA) showed that the pre-test scores for general mathematical achievement to evaluate the effectiveness of the intervention ($F(1, 329)=59.678, p=.002, \eta^2$).

The Table 4 Mean and Standard Deviation of mathematical improvement on addition according to the levels of grading. Likewise, the Table 5 Mean and Standard Deviation of mathematical improvement on addition according to the levels of improvement. The pre-test and post-test were taken by 335 students.

The Table 6 Comparison of student scores for counting in post-test: ANCOVA analysis.

The Table 7 Comparison of student scores for general mathematical achievement in post-test: ANCOVA analysis.

The Table 8 Frequencies of the two groups in the pre-test of addition.

The Table 9 Comparison of student scores for general mathematical achievement in pre-test: ANCOVA analysis.

The Table 10 Comparison of student scores for general mathematical achievement in pre-test: ANCOVA analysis.
agree with similar researches (Judge 2005; Keong, et al. 2005; Walcott, et al. 2009; Zaranis 2011) which implied that ICT helps students to understand mathematical concepts better which is crucial for their development. Also, the outcomes of the present study create a new teaching model with technological intervention which supports the growth of students. The method used was a quasi-experimental study which was a randomized control group. Total 2.04 2.586 113
Control 1.66 2.374 62
Low 51 30.91 62 36.47
Medium 71 43.03 58 34.12
High 75 45.035 21 13.72
Grading N f% N f%
Table 7 Frequencies of the two groups in the pre-test of counting

Thus, the students who had a good background with counting were treated in the same manner with those who had a similar achievement on addition.

The above discussion should be referenced in light of some of the limitations of this research. Firstly, the study was of small scale and context specific, any application of the results of this study should be considered with caution. Secondly, the undertaken computer assisted educational procedure, which is an ongoing challenge for the reflective teacher to decide how this technology, can be best applied in the learning process. Furthermore, the computer assisted educational procedure should not have a negative impact on the social interaction and the learning potential of the students. Lastly, our findings suggest that students with a medium-level of mathematical achievement in counting, who were taught with educational intervention based on KAM had a significant improvement, compared to those with high-levels and low-levels of achievement on counting. Zaranis, N., & Oikonomidis, V. (2009). ICT in preschool education. Athens: Grigoris Publications. [Text in Greek].


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learning at home and in the kindergarten classroom, Plowman, in the form of digital activities performed on smart mobile devices in kindergarten education. In particular, we will study the development of digital literacy, provide opportunities for independent learning and explorations, facilitate collaborative learning for young children, and encourage children to work together. They have been found to improve their ability to solve problems. Digital learning activities may impact the young child’s development, supporting the full range of the curriculum.

Researchers Christie and Johnson (2009) indicate that digital native three to six years old play with a vast variety of digital learning activities, now available on desktop monitors and portable devices. These activities consist of comparison, sorting, matching, counting, design, games, and even make use of numerous online services such as video-sharing, making and receiving VoIP calls using Skype. There have even been new partnerships with parents and guardians, including stimulus, motivation, ease of use, availability, etc.

The introduction of ICT (Information and Communication Technologies) in the field of Preschool Education has been a controversial topic, especially in the context of early childhood education. Most researchers and educators argue that ICT can be a valuable tool in the educational process because of their increasing accessibility and flexibility. However, some researchers believe that ICT should not be the main focus of early childhood education, but should be used as a complementary tool to support traditional teaching methods.

In the classroom, ICT is treated as a learning tool (Zaranis & Stephen, 2005; Plowman & Stephen, 2005; Somekh, 2007). For some children, the first educational experience with computers begins in the kindergarten classroom. These children and their parents. They very aptly report that technological knowledge even before attending kindergarten. Hertzog and Kalogiannakis, 2011a). For the students, ICT is a means for developing higher-order thinking skills, connecting and learning and exploring, and enhancing the development of understanding about the world (cognitive objects), the acquisition of functional skills (such as the operation of the mouse) as well as the development of digital literacy, providing opportunities for independent learning and explorations.

The extension of knowledge and learning outcomes in digital environments, at a variety of both formal and informal settings, is a highly significant aspect of ICT. Many researchers have studied the impact of ICT on the development of young children, and the results have been very promising. For example, Zaranis and Kalogiannakis (2011b) have found that the use of ICT in the classroom can facilitate collaborative learning for young children, encouraging children to work together. They have been found to improve their ability to solve problems. Digital learning activities may impact the young child’s development, supporting the full range of the curriculum.

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Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps). Similarly, the term smartphone describes mobile phones functionality and the use of third party applications (mobile keyboard, however, provide interactive capabilities via built-in apps).
Hermeneutic Unit: Systematic literature review relating to the use of IC...
a small sample of kindergarten students in specific geographic regions of Greece) allow us to assume the following:

As already mentioned, the purpose of this paper was to promote and develop the potential of children's mathematical knowledge upon beginning the kindergarten could be described as the ground level. In general, an elementary educational software for tablets produces better learning outcomes for the students, than software for computers. The teaching of Realistic Mathematics with the use of educational software App Inventor (AI) and were tested on the continuum education in order to systematically evaluate the integration of the AI on the activities and in the specific problem situation that the children were obliged to use their fingers or other representations for each round. As Van Den Heuvel-Panhuizen (2008) claims, this can occur in a variety of ways, including but not limited to, providing immediate feedback or contextual support. The research and development of the original applications was provided through graphic characters (e.g., the application of a "birthday hat") and the use of other natural objects. As previously stated, for the third level applications, objects are used to develop more complex counting tasks, e.g., "Johnny has 5 pieces of candy and his uncle give him?" Alternatively, in the case of subtraction, "Johnny has 14 pieces of candy but eats an unknown number of those bananas. The remaining bananas are displayed for a brief period of time before they are hidden. By previously removing from the equation. This way, the enumeration is no longer dependent on the objects themselves, and a mental calculation can be performed. Examples of third level portable applications.

Examples of third level portable applications.

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The creation of new applications that meet the demands of the children is limited by and focused on the tool itself rather than the curriculum but there are usually children who are able to work for each round. As previously stated, for the third level applications, objects are used to develop more complex counting tasks, e.g., "Johnny has 5 pieces of candy and his uncle give him?" Alternatively, in the case of subtraction, "Johnny has 14 pieces of candy but eats an unknown number of those bananas. The remaining bananas are displayed for a brief period of time before they are hidden. By previously removing from the equation. This way, the enumeration is no longer dependent on the objects themselves, and a mental calculation can be performed. Examples of third level portable applications.

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...
In such designs, it is sometimes possible to provide opportunities for learners to engage in meaningful mathematical activity that is not necessarily immediately linked to traditional classroom tasks. For example, in a recent study of the benefits of using technology in the mathematics classroom, Cockcroft (1982) highlighted the potential of such tools to support the development of meaningful and purposeful learning experiences. This potential is particularly evident when learners are provided with the opportunity to engage in purposeful tasks, which afford the possibility of pursuing mathematical ideas before any formal knowledge of the procedures and relationships associated with them. However, it is important to note that the potential for meaningful mathematical activity through the use of technology is not limited to classroom settings. In fact, the use of technology in the mathematics classroom has been shown to have the potential to extend the boundaries of mathematical learning, providing opportunities for learners to engage in purposeful tasks that are not limited to the classroom setting. For example, the use of computer algebra systems in the classroom can support learners in exploring mathematical ideas in a way that is more akin to mathematical research, rather than the more structured and formal approach that is often associated with classroom-based learning. Furthermore, the use of technology in the mathematics classroom can provide opportunities for learners to engage in purposeful tasks that are not limited to the classroom setting, thereby extending the boundaries of mathematical learning and providing learners with opportunities for meaningful and purposeful mathematical activity.

In our interpretation, the key notion here is that the students are making decisions for themselves in ways more akin to engagement with street mathematics than is typically the case in the classroom setting. This is in contrast to the more structured and formal approach that is often associated with classroom-based learning. We conjecture that engaging purposefully in the use of mathematical ideas in a well-designed task leads to learning which is different from that which might arise when mathematical ideas are presented as procedures or relationships to be learned and mastered. This inversion is made possible by the use of technology to offer opportunities for learners to engage in purposeful tasks, which afford the possibility of pursuing mathematical ideas before any formal knowledge of the procedures and relationships associated with them. However, it is important to note that the potential for meaningful mathematical activity through the use of technology is not limited to classroom settings. In fact, the use of technology in the mathematics classroom has been shown to have the potential to extend the boundaries of mathematical learning, providing opportunities for learners to engage in purposeful tasks that are not limited to the classroom setting. For example, the use of computer algebra systems in the classroom can support learners in exploring mathematical ideas in a way that is more akin to mathematical research, rather than the more structured and formal approach that is often associated with classroom-based learning. Furthermore, the use of technology in the mathematics classroom can provide opportunities for learners to engage in purposeful tasks that are not limited to the classroom setting, thereby extending the boundaries of mathematical learning and providing learners with opportunities for meaningful and purposeful mathematical activity.


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### References


perspective on a mathematical conception is opposed to a pure skill understanding of
considered from a tool perspective when they are part of a (problem solving)
technique, regardless of its being instrumented or not. The generation of the
actual determination or calculation of the derivative in question. The corresponding
involved in a specific context, by somebody, at a given time. A given tool may be
conception is in accordance with Régine Douady's de finition: 'We say that a concept
and an object perspective corresponding to a tool perspective, a unit is considered which
laptops. There is no symmetry between the four representations.
formation of (one or more) mental utilisation scheme(s). The term instrumental
corresponding object perspective could be the derivative, characterised or categorised
perspective on the conception of derivative of a function could be the derivative seen
change of perspective to support learning

to inquire how the teacher can provoke and support the students' change of perspective in both directions within these dualities, and to
tomorrow's learning. Flexibility incorporates this basic idea in the form of the aforementioned
b) Dualities of perspectives linked to the construction of epistemic knowledge: 4.
models and methods in a technological environment that is used for solving a specific type of
teaching materials (Hjersing et.al. 2004): The formation of utilisation schemes and the
pages in which the text is in a master

For more details about this course are available at the following address:

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The equilibrium point is a sink or a source? Use the answers to sketch (in hand) the right-hand side.

2. Find the general solution to the differential equation (8.2) (Show calculations).
are in the perimeter of an nxn grid. This note is as an example of a note coded as Level 1, given that the student presented his ideas in a straightforward manner, but did not engage in any form of justification or evidence. It is important to note that students engaging in collaborative problem-solving strategies often do not revise their initial ideas. The following note entitled "Relationships" was written by a student, SR, who engaged in a discussion with another student about the Perimeter Problem. SR's note included his strategy for solving the problem and contained some mathematical expressions, such as 

\[5 + 5 + (5 - 2x2)\]

The note also showed evidence of mathematical thinking, as SR revised his initial ideas to improve his strategy. This note was coded as Level 2, indicating that the student provided a conjecture that was somewhat supported by evidence. However, it is noticeable that some students recognized the need for improvement and sought to refine their ideas. For instance, SR revised his note to include the following expression, showing a deeper understanding of the problem:

\[5 + 5 + (5 - 2x2)\]

Although this expression seems to be a straightforward attempt to solve the problem, it is evident that SR's thinking evolved as he engaged in the collaborative problem-solving process. The database view for the Perimeter Problem, one of six, shows the evolution of ideas as students contribute their thoughts and engage in discussions. The database views are continuously evolving interactive discourse spaces, where each thread of conversation is documented, and webs of interchanges graphically represent student notes and the discussions created as part of the collaborative problem-solving process. Students can also use the graphics palate to create small circles that are referred to as "build-ons", i.e., responses to notes posted by other students. A diagram of the database view for the Perimeter Problem illustrates the former, with a view of the Perimeter Problem containing the following discussion, which began when a student posted a note containing his strategy for solving the problem:

\[5 + 5 + (5 - 2x2)\]

The note was a function of the three problem-solving strategies. It is evident that students are repeating the number of squares one more. However, when we looked at the level of evidence and justification offered, it was clear that students were repeating their strategies. The Level 3 notes went to a higher level of note, we wondered about the nature of these revisions. Students are asked to find a rule that will allow them to ascertain how many squares are shaded in a square grid shaded squares.

Evidence and Justifications

Our analyses revealed that there was an even distribution of the three levels of evidence and justification offered across the problem-solving strategy. I figured out the rule and it is the number times 4 (the four sides a square has is 4. It is -4 because when you are multiplying 4 each corner you double them). So now we can focus on this part: \(= (5-2x2)\) so \(5-2 = 3\) and the space left in...
understand mathematics and vice versa.


The computer has brought about a phase change in mathematics education. From the very start of the introduction of the computer in mathematics education the possibilities of this medium were seriously investigated, and software development has always been for innovation and improvement of mathematics education. From the very start of the design activities by the Freudenthal Institute over the last few years in the field of small didactical tools and microworlds (Java applets). This paper reports on the extensive design activities by the Freudenthal Institute over the 5x5 question you do 5x5=25 the square of 25 is 5 and you minus centre blocks to find the number of squares in the perimeter.

The objectives of the Freudenthal Institute are research and curriculum development for Research and Teaching, (pp. 87–106). Dordrecht, Netherlands: Kluwer.

The Freudenthal Institute, Utrecht University, the Netherlands.

Mathematics learning seems to be hard and exhausting task for many learners. Mathematics educators and teachers always try to stimulate the public and specially students as well.

Although our work is aligned with the general questions of classroom mathematics and parametric programs to provide mutual interactions between learners and mathematics learning. Using this tool, one can make some virtual spaces such as functional rule. As M and J state in their note (HP8), “the thing about math is to figure out the fastest and most accurate way to do things.”

This last discussion comes from the Handshake Problem. This problem, which involves the calculation of the number of handshakes that can take place in a group, is a good example of the kind of problem that can be introduced through an interactive microworld. The objective of this microworld is to help students understand the mathematical reasoning behind the solution of this problem.

There was a definite change from simple counting to the use of patterns. There were many instances of exchanges in which individuals extended the ideas of others. For example, M offered a pattern that was not correct but which provided a basis for developing a correct solution. This pattern was then extended by several students, who offered improvements and suggestions for refining the pattern.

The first is from the Perimeter Problem. This discussion began with a solution that was incorrect but which provided a basis for developing a correct solution. This solution was then extended by several students, who offered improvements and suggestions for refining the solution.

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Next, students revised their own notes, and encouraged others to do the same. In this discussion, we find that students were able to extend and refine their own ideas, and also to learn from the ideas of others.

To conclude we present two discussions taken from two different pairs of problems students routinely offered evidence to support their theories and of justifications increased as the students gained more experience on KF. By the third week, students’ disposition for offering not just solutions for problems but offering explanations for their solutions increased. This increase in the number of explanations was accompanied by an increase in the quality of these explanations. Students were able to provide more detailed and well-organized explanations, and were also able to justify their solutions with more convincing evidence.

Mathematics learning is not just about solving problems, but also about understanding and explaining why certain procedures work. Throughout the database we found evidence of what Bereiter and Scardamalia have termed epistemic agency. Students revised their own notes, and encouraged others to do the same. In this discussion, we find that students were able to extend and refine their own ideas, and also to learn from the ideas of others.

Discussion

In response to AW’s note, SI offered a note in which he proposed a different rule for the 5x5 question. SI suggested that the rule should be the number of squares in the perimeter. This rule was then extended by several students, who offered refinements and suggestions for refining the rule.

The discussion ended by agreeing on the rule that the number of squares in the perimeter is the number of squares in the whole figure times 2. This rule was then extended by several students, who offered refinements and suggestions for refining the rule.

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To give an insight in the design activities and the development process, some researchers the challenge lies in the design of convincing learning trajectories that researchers the challenge lies in the design of convincing learning trajectories that can be used by schools and individual students to store the results of their work on problems that involve mathematical objects in a way that permits reasons. 39 simulating real-world objects and processes that form the basis of mathematical reasoning. 39 simulating real-world objects and processes that form the basis of mathematical reasoning. Three different kind of applets. The borders between these three categories are not clear.

For each category one or more examples are describe d and used to illustrate and evince their role in longer learning trajectories.

Reasons are built progressively upon the students' informal ideas and strategies. In the RME theory, real-world situations and experiences form the starting point of goals are built progressively upon the students' informal ideas and strategies. In the RME theory, real-world situations and experiences form the starting point of learning. For applet designers it is a challenge to exhaustively explore the dynamics of applet activities in the applets are 'real' for students, that is to say they already have a meaning in the real world. To develop realistic situations, the applets activities in the applets are 'real' for students, that is to say they already have a meaning in the real world. To develop realistic situations, the applets are 'real' for students, that is to say they already have a meaning in the real world.

In the RME view it is important that formal mathematics can be used in arithmetic. Processes such as addition and subtraction can be modelled by using realistic situations and experiences. For example, the block building environment (figure 1) gives the user the opportunity to see the effect of adding two numbers which has a different meaning in the real world. In the RME view it is important that formal mathematics can be used in arithmetic. Processes such as addition and subtraction can be modelled by using realistic situations and experiences. For example, the block building environment (figure 1) gives the user the opportunity to see the effect of adding two numbers which has a different meaning in the real world.

One example of this category is the applet 'Fruit balance of an equation' (figure 2). In this applet part of a set of fruits can be replaced by a number where the weight of one fruit is given. It is a nice exercise of the habituation. A developing the function and formula concept through a 'real' situation is a major requirement of the RME approach. It directs the student to desirable skills and giving room to personal strategies and the formal mathematics. So a model is more than a (visual) representation of a piece of abstract mathematics. First, it has to be developed as a social aspect – are useful (Gravemeijer et al., 2002).

Developing a joint methodology for comparing the influence of different forms of teaching on mathe matical performance is related to the question of how mathematics can be taught and learned in practice. 39 simulating real-world objects and processes that form the basis of mathematical reasoning. 39 simulating real-world objects and processes that form the basis of mathematical reasoning. It is a nice exercise of the habituation. A developing the function and formula concept through a 'real' situation is a major requirement of the RME approach. It directs the student to desirable skills and giving room to personal strategies and the formal mathematics. So a model is more than a (visual) representation of a piece of abstract mathematics. First, it has to be developed as a social aspect – are useful (Gravemeijer et al., 2002).

The third category contains applets that work on formal mathematical objects, like formulas, equations and graphs can be constructed and transformed. In these applets, mathematical objects and concepts.

• Applets that offer a mathematical microworld. In these applets mathematical objects like formulas, equations and graphs can be constructed and transformed. In these applets, mathematical objects and concepts.

• Applets that offer a 'virtual reality'

Applets that offer a 'virtual reality'

...
The notion of didactical functionality of an ILE (see Cerulli, Pedemonte, Robotti, 2006) is central and unifying role: on the one hand, the cross-experimentation aimed to explore the tool is used, especially when it is used outside the control of its designers or in mediation, social semiotics, theory of didactic situations (TDS), anthropological theory, Rabardel's methodological tool for exploration of the role played by theoretical frames.

In what follows we present these two facets of TELMA work, focusing on the modalities of employing the ILE in a teaching/learning process related to given contexts. It is structured around three inter-related components:

- modalities of employing the ILE in a teaching/learning process related to given contexts.
- the design and implementation by each research team of a teaching guidelines, developed through an on-line collaborative activity. On-line collaboration proposed related research activity, and developing common research methodologies.
- the specific role given to PhD students and young researchers.

Comparison of the forms completed by each team, and of the oral reports of the teams using these in the cross-experimentation.

Technologies for shaping mathematics teaching and learning activities and discusses contributions reports on the work developed within TELMA for analysing the theoretical basis of the individual studies, their methodologies and outcomes. We focus on the methodological frame the process of cross-team communication; the diversity of the theoretical frames we employed.

In order to point out and compare the preliminary results of the cross experiments a table summarises the ILEs chosen, the starting phase of TELMA was very challenging, requiring six teams with key research topics in the area of digital technologies and mathematics education, ERT are integrating activities, which aim to network European recognized research teams on the identified issues, and to favour the construction of shared scientific policy, building complementarities and common priorities.

Table 1: The tools employed by TELMA teams in the cross experiment

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Slate</td>
<td>Central aim is to address the lack of harmonised research in the field of digital technologies and mathematics education.</td>
</tr>
<tr>
<td>ETL-NKUA</td>
<td>Kaleidoscope's central aim is to address the lack of harmonised research in the field of digital technologies and mathematics education.</td>
</tr>
<tr>
<td>UNILON</td>
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</tr>
<tr>
<td>Aplusix</td>
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</tr>
<tr>
<td>MEPAH-Grenoble</td>
<td>Kaleidoscope's central aim is to address the lack of harmonised research in the field of digital technologies and mathematics education.</td>
</tr>
<tr>
<td>CNR-ITD, UNIVERSITY</td>
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</tr>
<tr>
<td>University of London, UK</td>
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</tr>
</tbody>
</table>

3. Cross-experimentation

The procedure employed for implementing the cross-experiments was based on the descriptions provided by the teams and analysis of the designs of the ILEs. Each team thus produced a report analysing the different contributions and developing them into an integrated presentation (the result is available at the TELMA web site) including the guidelines, developed through an on-line collaborative activity. On-line collaboration proposed related research activity, and developing common research methodologies.

An important role has been given to young researchers and PhD students.

The starting phase of TELMA was very challenging, requiring six teams with key research topics in the area of digital technologies and mathematics education, ERT are integrating activities, which aim to network European recognized research teams on the identified issues, and to favour the construction of shared scientific policy, building complementarities and common priorities.

The teams involved are described in Table 1, together with the theoretical framework that was used in the experiments. Each team has brought with it particular focuses and theoretical frameworks, adopted and developed over a period of time. Most of the teams have also contributed to the design of the experimental environment and developed it through the on-line activity. Each team thus produced a report analysing the different contributions and developing them into an integrated presentation (the result is available at the TELMA web site) including the guidelines, developed through an on-line collaborative activity. On-line collaboration proposed related research activity, and developing common research methodologies.

A cross-experimentation is a way to foster collaboration, seeking to understand the diversity of theoretical frames employed.

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possible, may also be populated by the role played by different agents. In the case of the project, this meant the role played by the researchers in the project as well as those of the teachers and students involved. The role played by the teachers and students is of particular interest in this context because it is related to the development of educational goals and associated potential of the ILE and mathematical knowledge (Alibali et al., 2003). This action may well be the rejection of a particular affordance in favour of another. This perception and subsequent enactment depends not only on "the environment. In line with Gibson, the environment includes both animate and inanimate objects (Gibson, 1986). The possible action on these objects and of the relationships between these objects may be explained a posteriori by referring to theoretical frames but had been used as "black box" but found this caused problems when pupils needed to make sense of matrices have been used to identify manifestations of affordances, affordance bearers and constraints and school praxis. As an example, we consider ARI-LAB2 (developed in Italy by the ITD team). ARI-LAB2 is composed of several microworlds designed to support the learning of mathematical content or practices. Teachers and students equally have to learn to adapt the feedback sufficient because the teacher's role and feedback are considered as fundamental as those of the ILE. During the cross-experimentations another aspect has been highlighted related to the feedback sufficiency. Similarly, the DIDIREM team decided to switch to other microworlds of the microworld in their school context due to the fact that Thales theorem is usually considered as a "black box" but found this caused problems when pupils needed to make sense of it. Therefore, it may be the rejection of a particular affordance in favour of another. This perception and subsequent enactment depends not only on "the environment. In line with Gibson, the environment includes both animate and inanimate objects (Gibson, 1986). The possible action on these objects and of the relationships between these objects may be explained a posteriori by referring to theoretical frames but had been used as "black box" but found this caused problems when pupils needed to make sense of matrices have been used to identify manifestations of affordances, affordance bearers and constraints and school praxis. As an example, we consider ARI-LAB2 (developed in Italy by the ITD team). ARI-LAB2 is composed of several microworlds designed to support the learning of mathematical content or practices. Teachers and students equally have to learn to adapt the feedback sufficient because the teacher's role and feedback are considered as fundamental as those of the ILE. During the cross-experimentations another aspect has been highlighted related to the feedback sufficiency. Similarly, the DIDIREM team decided to switch to other microworlds of the microworld in their school context due to the fact that Thales theorem is usually considered as a
Hermeneutic Unit: Systematic literature review relating to the use of IC...
Accordingly the student must be responsible and motivated to learn and furthermore environments. The model studies the elements of teaching based on the student's ability to learn. Teaching centered around student learning. Scarantino, A. (Dec, 2003). Affordances explained. Philosophy of Science, 70, 949-


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The evaluation phase

Evaluation shows the strengths and weaknesses of the learning process and products. It can be used for formative and summative evaluation. It can be carried out in both a qualitative and quantitative manner.

Evaluation is a key step in the design and implementation of a learning model. It can be used to assess the effectiveness of a learning environment and to make necessary adjustments.

In this section, we will discuss the various aspects of evaluation as they relate to the learning model. We will start by discussing the purpose of evaluation and the types of evaluation that can be used.

The purpose of evaluation is to determine whether the learning objectives have been met. Evaluation can be used to assess the effectiveness of a learning environment and to make necessary adjustments.

There are several types of evaluation that can be used. These include formative evaluation, summative evaluation, and diagnostic evaluation.

Formative evaluation is used to assess the effectiveness of a learning environment and to make necessary adjustments. It can be used to assess the effectiveness of a learning environment and to make necessary adjustments.

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Section 2: Evolving roles of technology in mathematics education at Brock

By 1995 a majority of students in all mathematics programs were using technology in a significant way. In general students were working with Computer mathematics laboratories. There they observed student activity and reflected on the Department's subsequent sustained development of the use of evolving technologies in its undergraduate mathematics programs. Although one can point to some didactical considerations that were introduced in MICA specifically for future summary of important aspects of the MICA courses; in Section 4, a description of role that evolving technologies can play in mathematics education; in Section 3, a development of technologies in mathematics programs at Brock; in Section 2, a discussion of one instruction; in the first box in Figure 1 and adds digital information to traditional forms of information learning environment, namely the digital information, data, equations, resources, etc. that are available through digital information, namely the digital information, data, equations, resources, etc. that are available through technologies;

Figure 1 Model of MICA courses in Calculus and Mathematics courses.

With the advent of digital information, namely the digital information, data, equations, resources, etc. that are available through technologies, the proliferation of interactive, engaging, easy to use, and environment building technology (e.g. VB.NET (3)), into an innovative core program "The Brock Teaching journal (5). Student interest in the MICA program is demonstrated by over 100 students who worked with Maple in a laboratory setting. In this presentation we propose a model for the development of the MICA program at Brock. The model is based on the premise that evolving technologies can play a significant role in the teaching and learning of mathematics.

The model will outline that technology, such as Maple, and Mathematica, are capable of generating new information. A definition of digital information, namely the digital information, data, equations, resources, etc. that are available through technologies, is provided by the following definitions:

1. Digital information – data, algorithms, responses, etc. that are available through technologies;

2. Instruction; and environment building technology (e.g. VB.NET (3)), into an innovative core program "The Brock Teaching journal (5). Student interest in the MICA program is demonstrated by over 100 students who worked with Maple in a laboratory setting. In this presentation we propose a model for the development of the MICA program at Brock. The model is based on the premise that evolving technologies can play a significant role in the teaching and learning of mathematics.

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Summer Workshop in Summer 2004. With mastery of technology and PDEs. Two students presented their remarkable MAPLET extension at the Maple modelling including for example heat flow and wave propagation. Guided Results and Analysis then systematically analysed for patterns in the dialogue, within and between the was produced in the same way as the first situation. The transcripts from both were primary schools, drawn from a wide range of socio-economic areas. There were four individuals interested in teaching must first graduate with a university degree and significantly more sophisticated than in MICA I, since they have a better mastery of research. Five weeks after the first data was gathered, a similar approach for data completed their investigation, and their written recordings were collected. This data,

Section 5: Reflections by a new faculty, Chantal Buteau

admit that it is a constant battle for me. When I was taught these concepts there was changing as I rethink what should be first discovered by students in a guided assignment using technology rather than directly presented to them. My conception of assignments and exams also had to be changed. As a new lecturer, it has been a

Teachable subjects are specified by the Ministry of Education as being appropriate major courses. Concurrent education students who aim to specialize in mathematics and to be certified for teaching at the middle and high school levels, take a majority of the The Mathematics Department at Brock has taken its responsibilities for future years. The Mathematics Department at Brock has taken its responsibilities for future years. Departments can take to integrate them into their mathematics programs. This

literature and the Faculty of Education. For those students who enter university with a desire to become teachers, language programs provide opportunities to what is called canonical mathematics.

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Fran: Using a spreadsheet made it more likely to have a go at something new because it does many things for you. You have unlimited room. You can delete, wipe stuff, numbers and decimals. This appears to indicate a greater propensity for exploration. "When you saw the problem, how did you think you would start?" the children asked about the investigation. The pedagogical medium through which they engaged in the task made it possible for them to see the problem in a different light.

Although this particular group didn't fully explore the relation of the base numbers to the multiplication, they describe the environment and evoke the potential for exploration. The spreadsheet groups progressed more quickly into exploring larger operations with patterns. As Jay said, "Let's just go on forever!" The structured, visual nature of the spreadsheet prompted the children to pose a new approach to the investigation. They could use the spreadsheet to create a table of values to explore patterns and relationships.

Sarah: Basically, if you times your number by a hundred, and then by 2, you get a series of values that you can explore. The spreadsheet environment shaped the sense making of the task for the children.

Jay: So the answer is terminating and in half lots. Let's try =0.125/2; gives 0.0625 - 0.25 - 0.125.

6 0.166666.. etc.

4 0.25

2 0.5

1 1

Jo: With two digits you just double the number. You take the zero out.

Rachel: We went through one at a time and solved them. We solved them on paper at first, then compared the numbers. The same results occurred, it was just a quicker way.

Group two likewise used this to begin the process of solving, but also to help solve the problem. "If you catch a pattern, you can see it in the spreadsheet," Sara said. "You can see the pattern there."

Greg: I type what I think and try it there and see if it works. It helps me think of different ways to solve the problem, like use a formula or the spreadsheet or the calculator.

Sara: Re-read to get into the math's thinking, then straight to a spreadsheet formula. The spreadsheet allowed us to see the pattern much quicker. It helped us find patterns in a more meaningful way. It helped us build up to the generalisation and see how it related to the problem.

"How do you think you could explain your mathematical thinking to someone else?" The children were asked. "We could explain it in a spreadsheet," Sara said. "We could use formulas and copy how it works.

References


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Understand both regularities and diversities. A regional project can, from a panel, choose their preferred EEB and the Region will work is altered. Building and the study of didactic situations where the "milieu" produces of the integration of ICT tools. Therefore EEBs are easier to integrate into their classroom practice. The teachers that we interviewed and observed engaged mostly in incremental change. However, to keep this teacher's individual meaning, it is necessary for the institution to guarantee a good technical material and to maintain the working pace of each student and to help them individually if necessary. So, it is a direct linked to ICT tools: the mathematics syllabus for high school requires students' adaptations to these modifications.

As previously mentioned, all observed sessions with EEBs are training exercises and would otherwise be sent back implicitly to a possible personal work. Thanks to the feedbacks.

The student's answer is the formula \( g(x) = (x/2) + 1 \). EEB's technical solving methods step by step. In the following example, students must give personal meaning to these sessions. So the hypothesis to explore here is: mathematical activities developed by an EEB use.

Chevallard's approach. They are described by three main components: the type of tasks, the techniques used to solve these tasks and the technologico-theoretical order to both explain and justify the techniques. The advance of knowledge requires useful in the learning process because it creates a link between algebraic frame and

We have seen that EEB sessions can increase students' activity. Now let us inquire with an EEB is funny but we will never have such exercises at the exam”. So a consequence from the dialectic between rules and individual meaning is: the more students' adaptations to these modifications.

From this answer, it is possible to produce a (g(x)) expression which can be a basis for the next activity. Students have the opportunity to try different approaches in order to verify their hypotheses. They also observe the consequences of these hypotheses. Once students have found a solution, they can share it with other students. They can also observe different solutions to the same problem. This encourages them to reflect on the different methods used and to compare them. It also helps them to develop their ability to think critically.

Exercises and open-ended questions are common in EEBs. They encourage students to think independently and to explore different solutions. In the following example, students are asked to find the equation of a line that passes through two given points. They can use different methods to solve this problem, such as finding the slope and then using the point-slope form or using a graphing calculator. This allows students to see how different techniques can be used to solve the same problem and to choose the one that is most appropriate for them.

For instance, if students are given a set of data points, they can be asked to find the equation of a line that passes through those points. They can then use this equation to predict the value of y for any given value of x. This helps them to understand the relationship between two variables and to make predictions based on that relationship.

Exercises in EEBs are often designed to be challenging. They require students to think critically and to apply the concepts they have learned in new situations. This helps them to develop their problem-solving skills and to become more independent learners. In the following example, students are asked to find the equation of a line that passes through a given point and has a given slope. They must use their knowledge of linear equations and algebraic manipulation to solve this problem. This requires them to think through the steps involved in solving the problem and to apply their knowledge in a strategic way.

Exercises in EEBs are often designed to be open-ended. They allow students to explore different solutions and to develop their own thinking processes. This helps them to become more creative and to think outside the box. In the following example, students are asked to find the equation of a line that passes through a given point and has a given slope. They can use different methods to solve this problem, such as finding the slope and then using the point-slope form or using a graphing calculator. This allows students to see how different techniques can be used to solve the same problem and to choose the one that is most appropriate for them.

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In this discussion I wish to tackle the issue of how digital technologies (DTs) shape the learning environment and the development of student thinking and problem-solving skills in mathematics education. The use of DTs in education has been widely discussed, with some researchers arguing that these technologies can enhance the learning process and improve students' understanding of mathematical concepts. However, the impact of DTs on teaching and learning is complex and multifaceted, and it is essential to consider how these technologies can be effectively implemented to promote student engagement and achievement.

One of the key challenges in using DTs in mathematics education is the need to balance the integration of technology with the development of traditional mathematical concepts and skills. While DTs can provide valuable tools for visualizing mathematical concepts and facilitating problem-solving, it is crucial to ensure that students develop a deep understanding of mathematical ideas through meaningful interactions with these technologies. This involves designing activities that promote critical thinking, reasoning, and problem-solving skills, while also allowing students to explore mathematical concepts in a dynamic and interactive way.

Another important aspect of using DTs in mathematics education is the need to consider the role of teacher knowledge and pedagogical content knowledge in the design and implementation of technology-based activities. Teachers must have a strong understanding of the mathematical content they are teaching and the pedagogical strategies that are effective in supporting student learning. This requires ongoing professional development and collaboration among teachers, who can share ideas and strategies for integrating DTs into their instruction.

In conclusion, the use of digital technologies in mathematics education has the potential to enhance student learning and engagement, provided that these technologies are integrated in a way that supports the development of deep conceptual understanding and critical thinking skills. Teachers and researchers must work together to design and implement effective technology-based activities that promote student learning and achievement in mathematics.
The graphic calculator has brought about changes in the curriculum, the teaching and learning of mathematics. This study aims to pursue answers to the following research questions:

1. How DTs support deep learning and teaching of mathematics is an important issue that needs to be considered in the classroom. How DTs mediate thinking and problem solving needs to be investigated. The ensuing discussions could aid in the discovery of new ways of understanding and solving problems. Here is a case of how DTs mediate thinking and part-whole relations. The study of these relations could aid in the discovery of new ways of understanding and solving problems. Here is a case of how DTs mediate thinking and part-whole relations. The ensuing discussions could aid in the discovery of new ways of understanding and solving problems.

2. Teaching strategies that teachers can use to produce students who are judicious users of technology. The four teaching strategies mentioned are (a) to promote careful use of graphic calculator, (b) to integrate technology into curriculum, (c) to make use of DTs for decision making and technology use, and (d) to promote the use of algebraic insight for overview and monitoring. This study aims to pursue answers to the following research questions:

(a) What are teaching strategies that teachers can use to produce students who are judicious users of technology?

(b) What are the implications of teaching strategies that focus on the use of graphic calculators in the classroom?

(c) What are the implications of teaching strategies that focus on the use of graphic calculators in the classroom?

(d) What are the implications of teaching strategies that focus on the use of graphic calculators in the classroom?

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(Z) What are the implications of teaching strategies that focus on the use of graphic calculators in the classroom?
Hermeneutic Unit: Systematic literature review relating to the use of IC...


In conclusion, the development of Graphs 'N Glyphs has been an iterative process of refinement and improvement. The software has evolved over time to incorporate feedback from educators, students, and other stakeholders. The ultimate goal has been to create an engaging and effective tool for teaching and learning mathematics. With continued research and development, we hope to further enhance the capabilities of Graphs 'N Glyphs, making it even more valuable for educators and students alike.
Two CDs and descriptions have been prepared and published. The paper explores and 10 curriculum of mathematics. The next step was to investigate (also to localize) the Software might provide tools that enhance students' actions and imagination. The

Reflecting on the actions and activities that are enabled by a new technology can be helpful for the implementation of the purposes, aims and didactical attitudes that are positive direction of upbringing improvement. In this case the implementation of information technologies is one of the most important means to direct the computerization of schools towards the workhshops to teachers to introduce them the software are being held. That is one of the strategies of information technologies implementation of the purposes, aims and didactical attitudes that are

Egle Jasutiene, Institute of Mathematics and Informatics, Lithuania

Developing Dynamic Sketches for Teaching Mathematics in Basic Schools

The main properties of software that supports teaching of mathematics using computer-based technology help to look deeper to theorems of mathematics of geometry is presented in static form in which the true and deeper meaning of a  

Sketchpad 3.11” [www.keypress.com/sketchpad/] was bought to all Lithuanian schools has been performed and it has revealed that just 27% of schools are actually implemented. The Geometer’s Sketchpad does not limit the possible number of solutions of quadratic equations (19), and circle and circular disk (116). Similar numbers of sketches are presented in brackets: linear function (146), rectangular hyperbola (17), exponential function (19), tangent functions (18), polynomial functions (27), logarithmic function (15), trigonometric sine function (15), inverse trigonometric cosine function (18), inverse trigonometric tangent function (15), inverse trigonometric cotangent function (15), inverse trigonometric secant function (15), inverse trigonometric cosecant function (15), and inverse trigonometric hyperbolic cosine function (15), inverse trigonometric hyperbolic sine function (15), inverse trigonometric hyperbolic tangent function (15), inverse trigonometric hyperbolic cotangent function (15), inverse trigonometric hyperbolic secant function (15), inverse trigonometric hyperbolic cosecant function (15), and inverse trigonometric hyperbolic tangent function (15)

The number of sketches in this sample is 1091. The number of dynamic sketches of function’s graph is 96.

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4) The number of dynamic sketches of function’s graph is 96. The number of dynamic sketches of function’s graph is 96.

Following the suggestions of Eglė, Jasutiene, Institute of Mathematics and Informatics, Lithuanian University, we decided to use the Dynamic Sketches created by computer provide the possibility of a deeper practicing of skill in a way that incorporated understanding or in simulations that are invisible. In most cases just desired result, i.e. the complete image, is displayed. For example, 123 steps have to be performed. For example, to 123 steps have to be performed. For example, to 123

...
The second sketch is intended to analyze: 1) how the change of the coefficients parameters, the obtained systems and the interpretation of their graphical representations may change or move and what to notice is provided together with the sketch. Sketches are created using "The Geometer's Sketchpad" (Jasutiene et al, 2003; 2005). All sketches were developed implementing solid methodology: 1) a short description of the problem should be given which includes an initial drawing of the problem, 2) after that teacher training and information dissemination were initiated, and right after that teacher training and information dissemination were initiated, and 3) how to solve the problem question: how many solutions the system of two linear equations may have? For this topic three dynamic sketches have been developed: 1) graphical solution of equation graph (x-a)^2 + (y-b)^2 = c, 2) how the change of the values d, e, and f result the graph of equation ax+by=c, and 3) when changing the values of equations' coefficients-parameters, the obtained systems and the interpretation of their graphical representations may change or move and what to notice is provided together with the sketch. The sketch illustrates the whole group of systems of equations where one equation is linear one and another's graph is circle. When changing the values of equations' coefficients-parameters, the obtained systems and the interpretation of their graphical representations may change or move and what to notice is provided together with the sketch.

In 2003–2005 more than 800 dynamic sketches were developed: compact disks "Sketchpad" (Jasutiene et al, 2003; 2005). Thus, The Geometer's Sketchpad helps to look at mathematics as an entirety rather than as a separate subject. The analysis of the block of these dynamic sketches reveals that the problem of visualization becomes related with function and the relation between different visual forms of function. To provide the entire picture of the topic the third dynamic sketch is developed; it illustrates: 1) how the change of values of the coefficients a, b, and c result the graphs of functions directly (Jackiw, 2006). The short description on what should be noticed is provided together with the sketch. Sketches are created using "The Geometer's Sketchpad" (Jasutiene et al, 2003; 2005). All sketches are provided in CDs with descriptions, that help to use the sketches, possibility to go back to the initial state always remains, 3) there is a help provided to students. To provide the entire picture of the topic the third dynamic sketch is developed; it illustrates: 1) how the change of values of the coefficients a, b, and c result the graphs of functions directly (Jackiw, 2006). The short description on what should be noticed is provided together with the sketch. Sketches are created using "The Geometer's Sketchpad" (Jasutiene et al, 2003; 2005). All sketches are provided in CDs with descriptions, that help to use the sketches, possibility to go back to the initial state always remains, 3) there is a help provided to students.

Levels of intervention of a Computer Algebra System. The levels of intervention of a Computer Algebra System (a CAS) offer the ability to work with a particular problem prior to any intervention and, for example, to analyze the systems of equations and a result of their solution in a hand written way. The level in which the student is working is either "a black box", or he or she could press certain buttons and see how the software responds and what results it produces. He or she could also type in certain commands and see the result. The level of particular commands to perform certain tasks in a CAS may vary from simple commands to very sophisticated ones, for example, if a problem requires analysis of a particular function and the relation between different visual forms of function. To provide the entire picture of the topic the third dynamic sketch is developed; it illustrates: 1) how the change of values of the coefficients a, b, and c result the graphs of functions directly (Jackiw, 2006). The short description on what should be noticed is provided together with the sketch. Sketches are created using "The Geometer's Sketchpad" (Jasutiene et al, 2003; 2005). All sketches are provided in CDs with descriptions, that help to use the sketches, possibility to go back to the initial state always remains, 3) there is a help provided to students.
Consider the following initial value problem:

\[ \begin{align*}
\frac{dx}{dt} &= f(x) \\
-x(0) &= a
\end{align*} \]

We solve it by using Numerical methods. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself. The constraint that we meet here is of a totally different nature: instead of limiting the solution of the given problem. This is not true anymore: pedagogical features have already been implemented in the CAS. The user can then be incited to learn the new theorem, and then becomes able to manipulate this theorem by himself.
Suppose that the student did not find how to solve the problem; he/she can ask for
named JCT decided to teach MatLab and to use it in every engineering cursus. 134
(ici le calcul d’une intégrale définie)” (Trouche 2005; private e-mail). More briefly:
theorems that the student does not automatically know.

change the institution’s culture in a larger scale (e.g., all the first year Foundation
involved.

to do. Actually, the usage of the step-by-step feature of the software can be
be an instigator to further mathematical learning. This is the case in (Kidron 2003)
the student can wish not only to discover it and to use it afterwards, but to try to have
technology to mimic human actions.

Today as in earlier times, there is much rhetoric about the revolutionary impact on
that is believed to herald a new era of more effective learning. With respect to the
students' learning that will result from bringing a new technology into the classroom.
the computerized learning environments: guiding students' command process

And, their uses in the curriculum of the Teacher Education Course. With this view, the
practical experience. Only theoretical concepts would not inspire teachers to adapt a
practically contribute to the professional growth of educators. Otherwise, we should see
the adoption of such environments.

With such an environment in schools, teachers will be able true activities,
acquaintance with the program, acquiring of new knowledge can be also
central role in the learning. The student involved in the learning process will be to
by using of the software, the student has now an opportunity to understand by some kind of

with the step by step process.
1. **Hermeneutic Unit:** Systematic literature review relating to the use if IC...
the situation are important constituents of learning to master complex situations in the future. How can we encourage prospective teachers to construct new knowledge? Studies of practitioners require forms of action learning. Reflections on and conversations with the 'why.' Especially with MILE, it is noticeable that they want to know how the test that). In that case, they want examples of good practice, ready-made solutions for the 'why.'

Peirce’s words that lends a kind of iconicity. On the second level the term meaning belongs to a sign? At first similarities and experiences will stimulate that. Intrinsic meaning and become signs only when we invest them with meaning. It seems that if these four prospective teachers put the iconic interpretations of the students explain to her that the teacher makes remarks about the way of thinking to their 'thinking' with materials we saw that they took an observer's point of view. They barely shift to an interpretant that is a part of the tools of the way of thinking. They use appropriate devices to stimulate their thinking. You can touch it. In the evaluation the students explain they find observing in MILE a difficult part.

Imagine: When the participants afterwards observed in MILE in pairs we saw that their view something new, they fall back on materials. The materials visualize what you are given information about materializing with some questions as guidance. They are happy with some examples of good practice, ready-made solutions for solving the problems. Together, we conclude that teaching a mathematics lesson does not be typified as follows:

- student teachers to investigate many aspects of mathematics education in primary school teachers, with content for primary mathematics teachers' education programs.
- mathematical language and the consequences for a didactical approach for Simulated Lesson; Department of Education, CU.
- Instruction for Simulated Lesson; Department of Education, CU.
- appropriate proof of the theorem.
- the main theorems in area.
- the main theorem is explained two properties it is
appearance of language in relation to the thinking processes. Second, we try to tie
the identification of language to the doings of the student. This is done
by examining the language of the student with attention to its relation to
the mathematical thinking (Cobb, 1987). The language of the student
and the observer (teacher) are interrelated through the communication
processes and the interpretations of the head, heart and hand of the
student. Two aspects of this communicational process are further
examined, those pertain to an authentic and an artificial relationship.

In order to identify the student's language, it is necessary to study
the way in which students are talking about mathematical topics. So, to
observe real life situations, we try to let student-teachers to develop
local theories. On the one hand, they have to study the way that students
are talking about mathematical thinking. Van Oers (2002) observed that
the development of children's perceptions is a social construct. The
student-teachers have to understand that the perception of the teacher
becomes more and more obvious. You mainly use the tiled square to
show on the one hand the number of tiles, and on the other hand the
way to arrange these tiles (Oers, 1997). Mathematics is a body of
knowledge that is largely expressed through language. The role of the
teacher is to encourage the students to express their thoughts and
ideas, and to help them formulate hypotheses and local theories.

In the evaluation of a discussion where a teacher, instructing a grade 2
class, uses the tiled square the question arose: what exactly did
the teacher mean by using the tiled square? Bas concludes: 'If you say "make
problems about this" the children will not understand what you mean.
We proposed two methods for an effective approach: to discuss the use
of mathematized language and to encourage symbolic representations
of the problem. The way in which the teacher explains the problem
is very important. The teacher explains the problem to the students
in a language-based manner. The teacher is not using the number of
tiles to instruct the students, but the way to arrange these tiles. The
teacher explains the problem to the students in a language-based
manner. The teacher is not using the number of tiles, but the way
to arrange these tiles.'

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teacher is to encourage the students to express their thoughts and
ideas, and to help them formulate hypotheses and local theories.

The precise relation between language and mathematics however is not
a straightforward one. The recent research has been driven, either in
teachers' education programmes or with support from governmental
practices, and it has been strongly influenced by the recent trends
of the doings of the student. Two aspects of this communicational
process are further examined, those pertain to an authentic and an
artificial relationship. In order to identify the student's language, it is
necessary to study the way in which students are talking about
mathematical topics. So, to observe real life situations, we try to
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(teacher) are interrelated through the communication processes and
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number of tiles to instruct the students, but the way to arrange these
tiles. The teacher explains the problem to the students in a language-
based manner. The teacher is not using the number of tiles, but the
way to arrange these tiles.
A few minutes later…

Teacher: Observe and study the graphics.

Teacher: Distance?

Rui: I don’t know…

Teacher: Distance?

Rui: This line is not what the robot route. It’s the distance.

Teacher: Yes?

Rui: Can’t be because the robot cannot walk backwards. And the robot has always to go ahead.

Ricardo: The robot cannot walk backwards. And the robot has always to go ahead.

Teacher: Ok. You think the robot’s route is straight.

Rui: This line is not what the robot route. It’s the distance.

Teacher: Ok. Ricardo. You’re right.

Ricardo: Yes. It’s the distance.

Teacher: Yes. It’s the distance.

When every group had solved the problem, they together, make a synthesis of the main mathematical ideas involved in the problem trying that, they together, make a shared repertoire emerged. The concepts.

1. We asked Pedro and João to imagine and draw a graphic that represents a robot moving from one fixed point. They present the following graphics:

   a) A robot moving in a straight line.
   b) A robot moving in a circle.
   c) A robot moving in a spiral.
   d) A robot moving in a zigzag.

2. The authors of this paper would like to acknowledge the collaboration of the other two colleagues of the project: Elci Alcione dos Santos and Luís Gaspar. We also acknowledge the support from Mathematics and Engineering Department (DME) and from Local Department of Animation and Multimedia.

3. In the research we carried out with K-8 students using robots Lego® and its programming as a taken-asshared resource allow students to visualize and apprehend what a robot can and cannot do. Using the robots, they can make a direct correspondence between the direct proportionality definition as a function and the robot travel relatively to its distance to the starting point.

4. The research took into account Situated Learning Theories (Lave & Wenger, 1991, 1991). This paper relates an activity realized with K-8 students using robots Lego® and its programming as a taken-asshared resource. The activities are supported by the Mathematics and Engineering Department (DME) and from Local Department of Animation and Multimedia.

5. The research is used on theoretical perspectives of Jean Lave and Etienne Wenger, which consider the community as a whole is engaged in a shared repertoire, which is a source of coherence of a community: mutual engagement, joint enterprise and shared domain.

6. The data collection followed a qualitative approach and it’s an interpretive nature. Methodology used has an interpretative nature.

7. In this transcription (due limitations of space) we mainly present students exhibiting the result of their work. We pretend students to learn direct proportionality, as a function. Direct proportionality is a type of correspondence of two variables, in which the ratio of the variables is constant. It is important to point out that it is not necessary to have prior knowledge in order to learn proportionality, since students can understand the different levels of proportionality by the reasoning of the meaning of the different segments of the graphic.

8. The research was developed in the 4th and 5th grade of a public school in the Island of Madeira, Portugal. The school has about 300 students, divided in 6 classes.

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Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

Relevant role as a mediator element in all this process.

For talking about practice.

Students recognize impossibility of executing a task without assuming it as an

resolution of proposed problems.

In spite of we are now in an initial phase of data analyses we can already foresee

helps to understand learning. It is important that students' engagement in school

is the shared meaning of this concept? (Skovsmose, 2005) 159

and, by implication, assumed:

(VCAA, 2002a) is strongly advocated. In the Mathematics section of the CSFII, the

focus in some of the work; teachers' and students' beliefs about and attitudes

Mathematics, 39 (1-3), 45-65.

February 2005 in Sant Feliu de Guíxols, Spain.

References

solving the previous described problem.

inability of them. This fact was evident, for instance, at the time when they are

• Using robots in mathematics class promotes an increment either in discussion

achievement, had higher computer ownership and held more positive attitudes

students' mathematics learning outcomes, (ii) identifying factors that may contribute

technologies explored. In this proposal, synopses of various dimensions of a

selection of the studies are presented. Taken together the studies reveal that gender

less interested in using computers.

• The most widely used mathematic-specific software applications were

lower grade levels, were more convinced than their respective counterparts that

The aim of this study, conducted in 2005, was to investigate and compare the use of

curricular and school factors are associated with the classroom use of

Computers were more widely used in single content areas

and that curricular and school factors are associated with the classroom use of

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The aim of this study was to investigate teachers' perceptions of the impact of

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The aim of this study was to investigate teachers' perceptions of the impact of
Some of the potential problems are considered that need to be avoided in order to ensure that an extensive project has started - "Curricula development and further education in mathematics". A particular problem is presented. When designing the new curriculum, it is important to consider the potential impact of using graphics calculators. Ilze.france@isec.gov.lv, evijamezi@e-apollo.lv


For all three, the same questions and almost identical response options were used. The Likert scale was from 1 to 7, with 7 = Very useful, and 1 = Not useful at all. Teachers were asked to rate the impact they believed the introduction of CAS calculators would have on: your teaching; student learning; the curriculum; and the assessment system. The Likert scale was from 1 to 7, with 7 = Very important, and 1 = Not important at all. Teachers were also asked to provide open-ended comments that would help them understand what, how and why to teach math in secondary school.

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There is a plan to also include in the curriculum Internet addresses relevant to mathematics, each topic being supported with solutions, and self-testing. Although similar teaching material is available on the Internet, our students are not able to take full advantage of it, as they do not possess the necessary skills and knowledge for it. Visualization is a key element in the teaching process. A feature which we study students highly appreciate is the usage of ICT in teaching math.

Seventy percent of the participants responded, that opportunity to use computer in mathematics has not been used in the learning process of students. 70% of the teachers of Latvia have access to the Internet, but only 42% actually use it for teaching. There is a lack of interactive materials, which are developed for the interesting subject standards in secondary education and corresponding subject sample program. 692 10th graders from 12 pilot schools participated.

In 1997 a project “Latvian Education Information Systems” (LIIS) was begun to develop computer technologies. The implementation/introduction began in the schools in 1998. The development of the content of mathematics for the secondary school, using computer as one of the means of teaching and learning mathematics, is a part of the project “Computers and Mathematics in Primary Education”. The objective of our work is to determine what to study at a specific point in time. The implementation stage performed by the teacher at schools is integral to the development of all the material (class samples, samples of different level problems, materials for self-study). We expect to obtain a completely new insight into the teaching of math in the new millennium.
ICT tools represent both affordances and possibilities for the user and amplification effect may be observed when technology simply supplements the range of tools. Recent and ongoing projects have revealed that ICT tools can be used for mathematics education, which has been in use since 1997. A main focus in this paper is to research how the teachers can provide a learning environment for the students' work with ICT tools in mathematics classrooms.

The ICT competence project was a part of the learning environment for mathematics. The project, which was named Learning Communities in Mathematics (LCM), involved schools, teachers and a group of didacticians. The project aimed to develop the students' competence to use ICT tools such that they could make good use of the tools in their work on mathematics. The project had two main phases, the first phase was from 1997 to 2001 and the second phase was from 2001 to 2004. The first two years of the project were dedicated to the development and implementation of the project, and the last year was dedicated to the evaluation of the project.

In the final part of the ICT competence project the students had a working situation (Kennewell, 2001). A task that is too open can be difficult for the students to work with because it can be hard to see the structure of the task. On higher levels in schools it is important to be able to judge and utilise digital tools and games, investigations, visualisation and publishing. On lower levels in schools it is important to be able to judge and utilise digital tools and games, investigations, visualisation and publishing.

In a development and research project named the "ICT competence project" the students were asked to fill in two numbers, which are numerator and denominator of a fraction. The teacher had planned for increasing openness and difficulty of the tasks as the students moved on to the following sheets. The teacher had planned for increasing openness and difficulty of the tasks as the students moved on to the following sheets. The teacher had planned for increasing openness and difficulty of the tasks as the students moved on to the following sheets. The teacher had planned for increasing openness and difficulty of the tasks as the students moved on to the following sheets.

To be able to judge and utilise ICT tools is important for the students' work on mathematics using computers. The students' work on mathematics using computers is an important aspect of the students' work on mathematics using computers. The students' work on mathematics using computers is an important aspect of the students' work on mathematics using computers. The students' work on mathematics using computers is an important aspect of the students' work on mathematics using computers.

The model of the project was developed in close cooperation with the students and the teachers. The model was developed in close cooperation with the students and the teachers. The model was developed in close cooperation with the students and the teachers. The model was developed in close cooperation with the students and the teachers. The model was developed in close cooperation with the students and the teachers.

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Hermeneutic Unit: Systematic literature review relating to the use if IC...


Vygotsky's Zone of Proximal Development (as the distance between what a child can achieve alone and what can be achieved with the assistance of a more advanced person or a reflective thought). The second extension is that of instructor. The second extension possesses greater expertise in an area of learning endeavor. The second extension of Vygotsky's Zone of Proximal Development (ZPD) by elevating computer and graphing calculator technologies beyond that of mediated actions. The modalities outlined in the profiles were used in different contexts and as a basis for interpretation. While the meta-modalities are hierarchical in the sense of the different degrees of sophistication, they nevertheless describe the varying degrees of sophistication with which students and teachers work with technology. While these metaphors are hierarchical in the sense of the different degrees of sophistication, they nevertheless describe the varying degrees of sophistication, they can be drawn upon in the same way as other members of a learning community. Doerr and...
in the classroom. At the beginning of the course and in the first of each year students were involved in ‘shadow’ teaching. This entailed shadowing an existing teacher for periods of time and being expected to take on teaching responsibilities. Teachers were then expected to provide feedback to the shadow teacher and discuss the experiences with students. This approach is designed to provide a more realistic teaching experience, and to encourage the development of a learning community among students.

Vignette 1

A second year student, Jarrad, was initially reluctant to participate in classroom presentations. Eventually, he became involved in the discussion by bringing forward a graphical representation of the concept of vector subtraction. This was followed by an animated discussion and interaction between Jarrad and his peers. The discussion led to the development of a mathematical model that was subsequently used in class. This example demonstrates the potential of technology to engage students in mathematical discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction.

Vignette 2

A third year student, Sam, initially resisted participating in classroom presentations. Eventually, he became involved in the discussion by bringing forward a graphical representation of the concept of vector subtraction. This was followed by an animated discussion and interaction between Sam and his peers. The discussion led to the development of a mathematical model that was subsequently used in class. This example demonstrates the potential of technology to engage students in mathematical discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction.

3.2.3.3. Theorising the role of the teacher

In this section, we will consider how the role of the teacher is theorised within the sociocultural framework. Specifically, we will explore the ways in which the teacher can act as a facilitator or a regulator of student learning. The teacher can be seen as a mediator of the student's access to the learning environment, providing guidance and support as necessary. The teacher can also be seen as a facilitator of student dialogue and cooperation, helping to create a collaborative learning environment. The teacher can also be seen as a regulator of the learning environment, setting the rules and expectations for student behavior. The teacher can also be seen as a facilitator of student self-regulation, helping students to develop their own learning strategies. The teacher can also be seen as a regulator of student motivation, helping to maintain student interest and engagement.

The role of the teacher is central to the sociocultural framework. The teacher can be seen as a facilitator of student learning, providing guidance and support as necessary. The teacher can also be seen as a regulator of student behavior, setting the rules and expectations for student performance. The teacher can also be seen as a facilitator of student self-regulation, helping students to develop their own learning strategies. The teacher can also be seen as a regulator of student motivation, helping to maintain student interest and engagement.

4. Conclusion

In conclusion, we have demonstrated the potential of technology to engage students in mathematical discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction. In these instances, technology has been used as a quasi-peer, assisting in mediating discussion and interaction.
that workshop, how we were working in groups, and they explained to us how kids start trying to help. So when we were doing that we were grabbing it. It was out of that week-end that I really understood the impact that graphics calculators mean. We weren't just doing, we were really understanding at a higher level.

Discussion

Sandra was teaching linear programming, a topic that deals with the kind of opportunities for students to use the graphics calculators instead of drawing graphs by hand. However, none of the teachers had yet found time to learn how to use these calculators. She contrasted this with the approach taken in the week-end workshop and felt that this was a missed opportunity for her students. Sandra realised how much they improved the thinking, more just as a tool to do graphs and things.

Case Study of an Experienced Teacher Learning to Integrate Technology

Sandra recognised her need to gain new ideas via collaboration with other more experienced teachers. She described previous workshops she had attended as "off-putting", and that other people are out there. So that was really the turning point for me to utilise and valuing and that sharing and learning from each other, and just to realise that could be used in everyday school classrooms, and to acknowledge of the importance of utilising the technology.

Table 1. Factors affecting technology usage

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students' perceived abilities</td>
<td>Perceived abilities of students, motivation, and behaviour</td>
</tr>
<tr>
<td>Access to hardware, software</td>
<td>Availability of technology resources, technical support, institutional culture</td>
</tr>
<tr>
<td>Zone of Free Practice</td>
<td>Level of knowledge and skills in using technology to teach mathematics</td>
</tr>
<tr>
<td>Zone of Promoted Activity</td>
<td>Teacher's pedagogical beliefs about using technology</td>
</tr>
</tbody>
</table>
| Case Study of an Experienced Teacher Learning to Integrate Technology

Sandra's Zone of Free Practice (ZFP) was 0, meaning she was not familiar with the potential of using technology in her mathematics teaching. She had attended previous workshops that were not helpful, and now she realised that there were other teachers who were using technology in their classrooms. Sandra was then, understanding the bigger concepts, rather than just pushing forward with the formal part of the course integrate computers and graphics calculators into their mathematics teaching and learning and how these might change over time or across school contexts. Zone theory and how these different types of knowledge and beliefs; technical support; institutional culture; knowledge of appropriate teaching materials; and beliefs about appropriate assistance – to incorporate the social setting and the goals and actions of the intended learning.
The benefits of using Internet resources in teaching are extensive and varied. Not only do they provide a wealth of information, but they also offer opportunities for collaboration and communication. The Internet can improve resource mobilization and make it possible to carry on research of others, but also they may have difficulty making their own work known.

The digital divide can be within a country as well as between countries, but this need not be. The Internet properly used has great potential for reducing this divide, for bringing the information age—and with it mathematics education—to every student. (ZFM)

Distance learning has great potential, especially to reach rural areas and to minimize the effects of distance. Particularly for part-time learners who must continue in full-time employment, the ability to get specialized training at convenient urban locations can be capital intensive, but sharing from country to country as well as within a country can considerably reduce the investment costs. What is needed? (199)

The ability of teachers to share their own experiences is critical to the success of any effort to integrate technology into teaching and their pedagogical beliefs. The case study of Lisa illuminated issues facing experienced teachers who are unfamiliar with new technologies in high school classrooms: Explaining an apparent paradox.

Equity and the development of children's action: A theory of human development. (2)

There is justifiable fear about the hegemony of American and European culture in the light of their own expertise and institutional context.

The role of the Internet in teaching and research has been given too little attention in mathematics education, particularly in developing countries and underserved groups. Not only do those with inadequate Internet connectivity lack access to the up-to-date information are in similarly short supply. There are programs, human development. (3)

Although the Internet first arose in a largely academic context, for the most part it is only in highly developed countries that primary and secondary schools, have extensive access. Although public primary school students in some areas in developed countries, including a number using a six part paradigm: pervasiveness, geographical dispersion, connectivity infrastructure, organizational infrastructure, technological developments are now available only on the Internet. Use of the Internet in teaching and research, particularly with respect to access, equity, and socio-cultural issues. In mathematics education, particularly in developing countries and underserved groups.
The use of internet resources in the teaching of mathematics is now widespread in many countries. The resources I consider here propose mathematics exercises with a view to making a first step towards the consequences on the learning processes. I study in this paper how students work and learn mathematics with these resources. I examine in particular how students’ actions can be realized with that instrument? A computer algebra system, for example, can help to solve a mathematical problem. An e-exercises resource helps to understand unexpected uses of a given artifact: the subject constructs theorems-in-action: propositions believed to be true by the subject.

The possibilities offered by an e-exercises resource: access to exercises chosen according to their title or to their mathematical theme, help, feed-back etc. are easily provided. The design of an instrument can be found for example in Artigue (2002) and Trouche (2004). It has been mainly used to understand the impact on the learning processes of the instrumental approach, and the notion of didactical contract, that I use to complement the instrumental approach. In this paper, I will focus on the notion of didactical contract.

The use of internet resources in the teaching of mathematics in non-conventional environments. The resources I consider here propose mathematics exercises with a view to making a first step towards the consequences on the learning processes. I study in this paper how students work and learn mathematics with these resources. I examine in particular how students’ actions can be realized with that instrument? A computer algebra system, for example, can help to solve a mathematical problem. An e-exercises resource helps to understand unexpected uses of a given artifact: the subject constructs theorems-in-action: propositions believed to be true by the subject.

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The possibility for students to work at their own pace, or to follow different paths, is a learning? One can easily figure that a student choosing to work during a whole one hour sessions. The pedagogical aspects implicit in the use of the computer have turned out to be much more complex than originally predicted and, in practice, compounded by the resources continues to be sporadic and unevenly distributed throughout the country’s territories. In the next section further interpretations in terms of didactic contract are developed. I present here briefly an example issued from a research with sixth grade students who used a computer to learn about proportionality. In a usual environment. However, we do not know what the students who practiced observed real improvements, but no significant difference between the groups mentioned here, we studied the evolution of the students’ ability to identify and solve proportionality problems before, during and after their work on the computer. We conclude that the computer was that of catalyst for pedagogical change (Valente & Almeida, 1997). Integrating (?) Technology in the Brazilian Education System

Lulu Healy, Catholic University of Sao Paulo (PUC-SP), Brazil

A developing agenda for research into digital technologies and mathematics education: An analysis of the potentialities of powerful tools

Alice constructed here an unexpected scheme, relying on a mathematical theorem-in-action: “The answer to a proportionality problem whose text comprises only division or multiplication, and that the expected result is a whole number. Thus she contrôlé d’environnements dynamiques. In Weill-Fassina A., Rabardel P., Engelbrecht, J. & Harding, A. (2005) Teaching undergraduate mathematics on the conceptual work. International Journal of Computers for Mathematical

Reflection about instrumentation and the dialectics between technical and theoretical grounding, Research in Collegiate Mathematics Education V, American Mathematical Society.

The consequences for learning.

Mathematical Society.
...concentrating our design efforts particularly in areas of mathematics whose current coverage has been highlighted as problematic in the official guidelines for the Brazilian Mathematics Curriculum published by the Ministry of Education and the State of São Paulo.

26 We are currently engaged in a CNPq funded project, AProvaME (Argumentação e Prova na Matemática), which aims to identify and develop strategies of justification of students' arguments. In this second strand, we are working with learners whose developmental trajectories are not yet well represented in the research literature: blind learners and learners with severe visual impairments. As researchers, we recognise that we still know relatively...
A final word

By its very nature, it might be that digital technologies do have considerable potential to offer in generating mathematical ideas or notions. However, it is also evident that they do not represent a response to an expressed need from the grass-roots of the mainstream schooling. Because of this policy, a number of the mathematics teachers did not represent a response to an expressed need from the grass-roots of the mainstream schooling. Because of this policy, a number of the mathematics teachers of the story."

In fact, that legend constitutes a formal guide for the student in order to execute the construction in turn, just as is the case with the menu for geometric transformations. The two case studies reviewed here (Hoyos, 2003; Hoyos, 2005) were constituted on the basis of the productions made by the most advanced students in each of the different learning environments (cf. Vincent et al., 2002; Hoyos, 2002; Hoyos, 2003). The two case studies reviewed here (Hoyos, 2003; Hoyos, 2005) were constituted on the basis of the productions made by the most advanced students in each of the different learning environments (cf. Vincent et al., 2002; Hoyos, 2002; Hoyos, 2003).

Aims, Methodology, and Some Results

Finally, from the approach Sfard proposes to learning as the development of a language, our approach, not unlike the process of instrumental genesis, is complex, time-consuming and linked to local considerations such as the characteristics of the learning setting, and the participants' activities, knowledge and former methods of construction. The theoretical framework is very much oriented to the concept of mathematical turn rules and to the use of technological tools. We assume that digital technological tools are not limited to the realm of the game, but can be potentials for mathematical learning. Thematically, the present contribution aims at articulating the theoretical framework with the findings from practice. The theoretical framework is very much oriented to the concept of mathematical turn rules and to the use of technological tools. We assume that digital technological tools are not limited to the realm of the game, but can be potential for mathematical learning. Thematically, the present contribution aims at articulating the theoretical framework with the findings from practice.

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Sfard emphasizes that the introduction of new symbols acts as a piston, driving and mobilizing other factors in the process of learning. Here, the notations are considered a more by-product than a reason for the development of the concepts.

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Nonetheless, the measurement the software displays when one selects three points — were asked to measure an angle like that indicated by an arc in greater than 180º. 'Cause it wasn't Marcel (M) [The most advanced student in that study case-]: Do you know why it's the arc or its opposite. Perfect.

I: Marcel is right, since you have to label three points to measure an angle, as the legend in Help says, the angle the software is looking at could be the one marked by the arc or its opposite. Perfect.

M: I see how I can do it. 360º-148.9º, this is the angle labeled by the arc, [because] the 148.9º is the one that the arc didn't label. So, if this is what this angle measures,

I: Right. Has what we've done been interesting for you?

M: There is no such thing as uninteresting things, only interesting ways of doing things. After today, when I'm going to have to measure angles, I'll have to calculate it in my head and check it with the software. I'll be able to calculate the complement.

I: You learn more with computers, is that what you think?

M: I'm not sure, but I'm learning to think in a different way. I'm learning to think about space, lines, angles and turns.

I: Yes. Did you like the computer work?

M: I didn't like it at first, but I've changed my mind about it. I get what you need from the tools, not in that one [Logo], you gotta be calculating 'n' the computer you don't have to know how to do it, you get it from the tools.

I: You can learn a lot with the computer, you can learn a lot with this motor. [Marcel points to the motor of the robot]. The robot has helped me a lot too.

I: You learned a lot from this activity, didn't you?

M: I've learned a lot.

I: One of the lines of research into the question of semiotic mediation (Mariotti, 2002) looks into the cognitive processes of instrumental genesis, with the source of its production being the result of the subject's activity. The motor can be seen as a semiotic member of the family of teaching machines, which includes physical and virtual manipulatives, computer simulations, computer-based exercises, computer-assisted instruction and computational tools.

I: How far can ICT improve the learning of mathematics?

The proposed paper addresses the theme "Innovations and creativity" by highlighting the role of technology in primary mathematics classrooms. The paper critically reflects the current international situation and discusses the key challenges facing mathematics education in the context of technological advancements. The paper aims to provide insights into the potential of ICT tools in enhancing the learning and teaching of mathematics at primary and secondary levels. The paper concludes by outlining the implications for educational policy and practice, emphasizing the need for a balanced approach to the integration of technology in mathematics education.

The course is based on research findings that students learn more mathematics, more quickly, and in a more meaningful way when they are actively engaged in doing mathematics. This is because active engagement requires students to make sense of what they are learning by constructing their own knowledge. ICT tools can facilitate this process by providing a range of activities that engage students in doing mathematics. These activities include problem-solving, inquiry-based learning, and collaborative learning. ICT tools can also be used to support the development of mathematical reasoning and communication skills. The paper concludes by outlining the implications for educational policy and practice, emphasizing the need for a balanced approach to the integration of technology in mathematics education.
Using Pip in the context of length measurement encourages children to estimate the size of different geometric shapes. They could develop estimation skills with respect to the size of different shapes. Pip has also been used successfully in grade 4 classrooms with respect to the understanding of 90°, 180°, and 360° angles as a basis for finding and estimating angles. However, Pip allows the introduction of the angle concept in a hands-on and engaging way, and provides opportunities for children to explore and develop their understanding of angles through practical activities.

### Program Pip

Pip is a software tool used for creating dynamic geometry activities. It allows users to design and customize interactive geometry tasks, which can be used to enhance students' understanding of geometric concepts. Pip provides a platform for educators to develop engaging and interactive learning experiences that facilitate the development of students' spatial reasoning and geometric thinking skills.

### Program Pip in the Classroom

Pip can be used in the classroom to facilitate interactive geometry activities. For example, students can be encouraged to draw the graph that would capture the story of a non-linear function. This activity involves students in actively engaging with the concepts of graphing and understanding the relationship between variables. Furthermore, Pip allows for the creation of dynamic geometry tasks that can be used to explore and develop students' understanding of geometric concepts.

### Program Pip and Learning Outcomes

Using Pip in the classroom can lead to improved learning outcomes. Students who engage with dynamic geometry activities using Pip tend to have a better understanding of geometric concepts, improved spatial reasoning skills, and enhanced problem-solving abilities. Additionally, using Pip can help to engage students in the learning process, increasing their motivation and interest in geometry.

### Conclusion

Program Pip is a valuable tool for educators looking to enhance students' understanding of geometric concepts. By using Pip, educators can create dynamic and interactive geometry activities that engage students in the learning process and improve their understanding of geometric concepts. Through the use of Pip, educators can facilitate the development of students' spatial reasoning and geometric thinking skills, leading to improved learning outcomes.
When users create a new parameter, they specify initial values for activity, and number of jumps = 4 and jump by = 6 in the Jump Along activity, are different values. In communicating with each other and with a teacher, students move activity's unfolding on a single computer, and at any single moment in time across activities involve changing parameter values. Thus both over time within the domain itself; but they are brought into particular focus by Dynamic Geometry's like big numbers!—"but you don't necessarily wind up on the same spot").

While we have yet to study student learning and engagement with these activities sufficient capabilities to permit advanced users—in this case, curriculum treatments in terms of their intended age level, their use of Dynamic Geometry is not as markers of a real continuum, but rather as another counting system of non-quantitative—avoid the discrete formulations so common elsewhere. Thus the three angles are continuously-varying geometric quantities; there may be no "blinks out" of existence. Thus on top of the continuous phenomenon of point location is layered a visual signature (numbers that can be reached only by the smallest jumps). 239

A final response is that the general-purpose tools such as Sketchpad provide for the preferred number of visible decimal digits can be adjusted to display these as.

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it very useful for both myself and the candidates to take the time to collate this data

In addressing both professional development and distance learning (Roth, 2005; 2000; Ontario Ministry of Education, 2005), this reality is clearly, and in an ever-expanding manner, evidenced within pre-service and in-service teacher training programs across North America. Full-distance education has both benefits and drawbacks for the candidate and for the online instructor. Mathematics education, by the very nature of its content and methodologies, definitely adds to the mix (National Council of Teachers of Mathematics, 2000; Ontario Ministry of Education, 2005).

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While teaching in an Additional Qualifications (AQ) on-line learning courses in Canada, I have attempted to develop several strategies that I believe, based on observations, the following paper presents four key strategies for bridging this technological gap in the delivery of quality on-line professional development for mathematics educators. In addressing both professional development and distance learning (Roth, 2005; 2000; Ontario Ministry of Education, 2005), this reality is clearly, and in an ever-expanding manner, evidenced within pre-service and in-service teacher training programs across North America. Full-distance education has both benefits and drawbacks for the candidate and for the online instructor. Mathematics education, by the very nature of its content and methodologies, definitely adds to the mix (National Council of Teachers of Mathematics, 2000; Ontario Ministry of Education, 2005).

I would like to share with you four of the most interesting strategies I have employed in these courses. With a great deal of interest in addressing both professional development and distance learning (Roth, 2005; 2000; Ontario Ministry of Education, 2005), this reality is clearly, and in an ever-expanding manner, evidenced within pre-service and in-service teacher training programs across North America. Full-distance education has both benefits and drawbacks for the candidate and for the online instructor. Mathematics education, by the very nature of its content and methodologies, definitely adds to the mix (National Council of Teachers of Mathematics, 2000; Ontario Ministry of Education, 2005).

First, it is very important to actually situate learners within a visual context, allowing them to obtain a general understanding of the course before they actually begin to engage with the content. Classroom arrangements but because of their ant-like perambulations when wandering.

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Problem: Strider and Boromir are sitting at a back table in a dark, smoky tavern of As this represented a difficult "two-pipe" problem, they had to wait some time the math problems, I have found it beneficial to maintain a separate folder 250 question, consolidation of learning, and the encouragement of invented algorithms resources and links. Candidates are asked to have relevant software "up and running" the multiple solutions that are often presented by candidates lead to important are selected for the course, one being featured for each of the on-line names or leave the characters anonymous.)

Question: What was Gandalf's conclusion, and why was it the only fair and just way hobbit depart but then become puzzled as to how they should distribute the gift. Further, think of as many different ways (at least 251
In an attempt to overcome these difficulties, and to take account of relevant research set out in the Stellenbosch Declaration. It does this by reporting on the development of 3DMath software designed to accompany the 3DMath software.

The main purpose of 3DMath is to enhance students' understanding of 3D geometry education materials, preparing reports, printed material, etc. 258

The following features are thought to contribute to the development of 3D geometry education, and in 2D software can be effective in improving practice, decision-making, and resources development. However, the software needs to be located and to provide an open independent view. For example, students need to be able to represent a solid in 3D, or its correspondence in textbooks or other static resources.

The software needs to allow students to see a geometric solid represented in several possible ways on the screen and to transform it, helping students to acquire the ability to remain unconfused by the changes in the orientation of visual stimuli. The 3DMath software is being designed so that students can construct, observe and manipulate geometrical figures in a 3D-like space.

Based on the above theoretical perspectives, and the rich concept of visualisation in several possible ways on the screen and to transform it, helping students to acquire the ability to remain unconfused by the changes in the orientation of visual stimuli. The 3DMath software is being designed so that students can construct, observe and manipulate geometrical figures in a 3D-like space. To meet these purposes, the design of the proposed software followed three major fields of educational theory:

(a) the constructivist perspective about learning which argues that learning is personally constructed and is achieved by designing and making artifacts that can be used by another person to manipulate, reason or discover. In this way, the design of the proposed software followed the constructivist perspective about learning.

(b) the semiotic perspective about mathematics as a meaning-making endeavour which argues that any single sign (e.g. icon, diagram, symbol) is an individual, and personally constructed and is achieved by designing and making artifacts that can be used by another person to manipulate, reason or discover. In this way, the design of the proposed software followed the semiotic perspective about mathematics as a meaning-making endeavour.

(c) the fallibilist nature of mathematics which argues that mathematical knowledge, such as constructivism, and by semiotics. This is so that the pedagogy is fully integrated as a basis for

In the field of ICT-supported learning, pedagogy and technology have often been treated in isolation. This paper is offered as a modest contribution to meeting the challenges to enable conception of the many positive experiences already taking place in order to reach a genuine social and individual change. The relations modeled with the hands can be so bad, 256

44, and develop abilities of visualization in the context of 3D geometry. The following section discusses the definition of reliable innovative reference models and its role in the development of reliable innovative reference models.

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The software needs to allow students to see a geometric solid represented in several possible ways on the screen and to transform it, helping students to acquire the ability to remain unconfused by the changes in the orientation of visual stimuli. The 3DMath software is being designed so that students can construct, observe and manipulate geometrical figures in a 3D-like space. To meet these purposes, the design of the proposed software followed three major fields of educational theory:

(a) the constructivist perspective about learning which argues that learning is personally constructed and is achieved by designing and making artifacts that can be used by another person to manipulate, reason or discover. In this way, the design of the proposed software followed the constructivist perspective about learning.

(b) the semiotic perspective about mathematics as a meaning-making endeavour which argues that any single sign (e.g. icon, diagram, symbol) is an individual, and personally constructed and is achieved by designing and making artifacts that can be used by another person to manipulate, reason or discover. In this way, the design of the proposed software followed the semiotic perspective about mathematics as a meaning-making endeavour.

(c) the fallibilist nature of mathematics which argues that mathematical knowledge, such as constructivism, and by semiotics. This is so that the pedagogy is fully integrated as a basis for

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44, and develop abilities of visualization in the context of 3D geometry. The following section discusses the definition of reliable innovative reference models and its role in the development of reliable innovative reference models.
The potential layers of learning

- Multiplayer game over the web: Players can compete for example to land with the best autopilot program, by recording what is deemed a good landing and then tweaking the parameters of the recorded landing to produce an optimal landing. The metagame starts with the player being hired as a game developer at a game company.

- Game construction: the interface consists of one or more code boxes. A picture can be given a behaviour by placing a picture and an arrow with the picture next to it. The program code consists of formal statements. The tools for this layer are basic, perhaps only a handful to control a game. Conventionally, designing a digital game involves choosing a programming language, building graphics, animations, and sounds, programming the story, and then tweaking the parameters of the recorded landing to produce an optimal landing.

- Narrative metagame: the Activity Sequence consists of a unique perspective when giving an explanation of the component which consists of one or more code boxes. A picture can be given a behaviour by placing a picture and an arrow with the picture next to it. The program code consists of formal statements. The tools for this layer are basic, perhaps only a handful to control a game.

- Modelling the same phenomena: elements have been given programs. The control panel also has a button that causes a virtual world where the laws of gravity and momentum are not obscured by friction to be shown. To proceed to this phase, all the required game-making tasks in Phase 1 need to be performed. When gravity is introduced, players can use the virtual world to study the effects of gravity on objects in motion. For example, they can launch a virtual ball and observe how it behaves under the influence of gravity. The second design requirement is worthy of particular attention, as it implies that the students are engaged in designing and building their own digital games. The third design requirement is that students are encouraged to explain their reasoning, reasoning, and learning in a digital world. The fourth design requirement is that students are encouraged to explain their reasoning, and learning in a digital world. The fifth design requirement is that students are encouraged to explain their reasoning, reasoning, and learning in a digital world.

- Collaborative interactions as part of the activity sequence through which students can share their experiences and reflect on their work. This is a unique feature of the Knowledge Lab, notably of Gordon Simpson and Diana Laurillard. The Knowledge Lab provides a framework for designing for this learning: flexible tools that have adjustable parameters, can be combined in different ways, and can be also be programmed, and thus allow students to manipulate each activity for learning more effectively.

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Bruner defines constructivist learning as an active process in which learners construct new ideas or concepts based upon their current and past knowledge. This approach was developed by MOE in the 1980s, and has become the basis of our mathematics education. It was based on the development of conceptual understanding through carefully planned, pedagogy-driven model for the development of learning resources for mathematics:

- Use of mathematical tools
- Data analysis
- Thinking skills and heuristics
- Confidence
- Appreciation
- Interest
- Self-regulation of learning

The Singapore school mathematics framework has 5 inter-related components, which are based upon these models and which concepts are to be constructed upon these models: (1) Development of conceptual understanding through careful planning, (2) Integration of IT and Pedagogy, (3) Development of teachers, and a paradigm shift in teaching and learning. This would require curriculum and pedagogical changes, the professional development of teachers, and a paradigm shift in teaching and learning. For mathematics education, the emphasis is on the possibilities offered by IT for learning. For mathematics education, the emphasis is on the possibilities offered by IT for learning.

We are constantly improving the way we teach mathematics, paying greater attention to the promotion of mathematics. Teachers generally have acquired basic proficiency in IT knowledge and skills. Many schools have an IT infrastructure with a good range of learning resources. Teachers generally have acquired basic proficiency in IT knowledge and skills. Many schools have an IT infrastructure with a good range of learning resources.

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Before this they had been trying to reduce the velocity to the minimum regardless of the horizontal and vertical rock throwers to the astronaut and using both simultaneously. Two – Tess and Alex – volunteered that the lander game would be different from the rocket games. Perhaps the most interesting suggestion was that the software might be structured into what they described as "levels", such as those commonly found in computer games. The students found this relatively easy to put in place and interpret their output. Students found this relatively easy to put in place and interpret their output.

Concerning the student's involvement in the simulations, they had already come to understand the necessity of using IT for learning in the classroom. They were also able to see that the process of learning mathematics through computer modelling can be a highly motivating activity, especially for Year 7 boys. Collaboration centered around group work, where they had to discuss their strategy and, in turn, students were able to share their thinking and strategies. The students were able to modify their strategies and, in turn, students were able to share their thinking and strategies.

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Now, we learned through this project how learning through simulations can support the development of new ideas. If we were to implement this simulation in the classroom, we would need to develop the IT infrastructure and the use of the horizontal rock thrower against the speed of the rocket which was implemented in the previous project. The software might be structured into what they described as "levels", such as those commonly found in computer games. Different simulations such as those commonly found in computer games. Different simulations might be used to support the development of new ideas.

This approach was developed by MOE in the 1980s, and has become the basis of our mathematics education. It was based on the development of conceptual understanding through carefully planned, pedagogy-driven model for the development of learning resources for mathematics. Teachers generally have acquired basic proficiency in IT knowledge and skills.

However, the use of IT in the classroom has been limited. Although students have had opportunities to use computer-based packages in the classroom, they have not had the chance to use it extensively. This is a particular concern for Year 7 students, who often have to rely on traditional methods of teaching and learning. Students have had limited opportunities to use computer-based packages in the classroom, they have not had the chance to use it extensively. This is a particular concern for Year 7 students, who often have to rely on traditional methods of teaching and learning.
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Irit: We worked on several examples in which we noticed that the more points, the more influences the students' thinking. In addition to the error due to the discretization of the source of error is the fact that in the numerical method the limit has been omitted. The students' attention might be distracted by the round-off error especially if in the analytical behavior is also involved. The students' attention might be distracted by the round-off error especially if in the analytical behavior is also involved.

"The round-off is not the crucial part. There is a change in the analytical behavior that is due to the step size." This is an important conclusion to make.

"The software has some limitation concerning the number of digits after the decimal point and it seems that this fact has enough strength (due to the accumulative effect) for some situations. But, this might not be true in some cases."

"We have worked this week an exercise that demonstrates that a small change in the step size can lead to a significant change in the solution."

"We do expect for a change due to the round off, but we expect to a change "in the analytical behavior." The round-off is not the crucial part. There is a change in the analytical behavior that is due to the step size."

"Maybe the small error made in the Euler's method induced big changes in the graph because the equilibrium solution". In connection to the metaphor of the straw and the camel's back, the student added: if there was no equilibrium line, the camel would not have been able to carry the straw.

"The belief that gradual causes have gradual effects is 23% of the answers expressed well developed qualitative approach to differential equations. These processes are means of mental images created by previous experiences with the instrument. These processes are means of mental images created by previous experiences with the instrument. The process of an artifact becoming an instrument in the hands of a user -- in our case the student -- is called instrumental approach. In line with the cognitive ergonomic framework, some researchers (e.g., Trouche, 2000; Drijvers, 2003) see the development of schemes as a qualitative work, rather than as obstacles. However, a precondition for these conflicts to foster learning is the development of schemes and their connection to the development of schemes. The thematic presented herein is that of equivalence, equality, and equation. The notion that schemes are broader in meaning than procedures and concepts (Artigue, 2002). The notion that schemes are broader in meaning than procedures and concepts (Artigue, 2002).

The students also pointed out the fact that the error in the numerical method accumulates. The students also pointed out the fact that the error in the numerical method accumulates.

"Before being exposed to the logistic equation, the students were asked to express their opinion about the following statement: "If in Euler's method, using a step size that is very small, there is a change in the analytical behavior.""

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Student could deduce the pattern without explicit instruction, and concluded, "I think since it's switching them both that it works out. Let's just say x was 0, then if you look at the one on the left, it is true, and if you look at the one on the right, it is true."

The teacher, however, did not provide any evaluation on the student's statement. The teacher did not explore questions related to the output of the CAS test, such as questioning its validity or exploring the possibility of receiving a different output. Instead, the teacher did not engage in any discussion about the output of the CAS test, and the student's response was not questioned further.

The case of Suzanne highlights the teacher's lack of engagement with the CAS output, and the student's active participation in the classroom discussion. However, the teacher's failure to address the CAS output raises questions about the potential impact on student understanding and engagement in the classroom. The teacher's approach may have limited the opportunity for students to critically evaluate the CAS output, and to develop a deeper understanding of the mathematical concepts involved.

In conclusion, the case of Suzanne provides an example of how the use of CAS in classroom settings can influence student engagement and teacher discourse. The teacher's lack of engagement with the CAS output may have limited the opportunity for students to critically evaluate the output, and to develop a deeper understanding of the mathematical concepts involved. The teacher's approach may have limited the opportunity for students to critically evaluate the output, and to develop a deeper understanding of the mathematical concepts involved.
Statistical literacy is vital to all aspects in our lives that deal with data based on mathematics. Teachers, including mathematics teachers, are still slow in adopting technology in their teaching. Since mid-2003, the Ministry of Education (MOE) has been sponsoring educational officers and mathematics teachers to attend short-term GC training courses or workshops as part of the Digital Math Initiative (DMI) and the successful implementation of the first course in statistics. Even though many research findings (Kissane, 2004; Rosihan & Kor, 2004) reported that not all teachers had exploited the full potential of the GC, most felt that the MOE's recommendations were not implemented. GC, as part of the solution, inevitably helps to provide impetus to intensify the use and potential of technology. Technology can help instructional designers and trainers to build more culturally sensitive lessons and activities. Furthermore, technology can help to address the issue of the misconception concerning the cultural differences in teaching and learning. Lessons on the integration of technology could help instructional designers and trainers to build more culturally sensitive lessons and activities. Furthermore, it is in the integration of technology and the technological curriculum innovations. These changes are expected to influence the way in which both students and teachers view mathematical knowledge and the role of technology in mathematics education. The impact of the use of graphics calculator on the learning of statistics: a study of thought in relation to instrumented activity', European Journal of Mathematics 43, 1–30.


In sum, we observed that the Malaysian students' experience in engaging GC to learn mathematics was encouraging. The students were generally positive in their perceptions of using GC. Most students felt that GC helped them to understand the subject matter more easily and to grasp the concepts better. They also found that GC helped them to solve problems more efficiently. One student commented, "I find that I work harder now in this subject… always rush to finish off the given tasks." Another stated, "We were hardly active in the classroom norm. It was observed that the classroom atmosphere was lively and cheerful. Time passed by without anyone noticing as most of the respondents were engaged in GC activities.

However, some students had different views. They expressed concerns about the cost of using GC and the lack of facilities provided in the classroom. They also felt that the GC was not always available when they needed it. One student complained, "It is very difficult to remember the function of GC. We were sent to different rooms to learn different commands and found it confusing.

In general, the engagement of GC in the statistics lessons had motivated students' learning attitudes. The students' engagement in the learning process was evident in their written reflections and audio taped interviews. They expressed their satisfaction with the use of GC in the classroom. One student stated, "I find that I work harder now in this subject… always rush to finish off the given tasks." Another commented, "I find that I understand the subject better now with the aid of GC."

The students' positive experiences with GC in the classroom were also reflected in their engagement in the learning process. They were more active and participative in their learning. One student commented, "I am now more active in class and I engage more with the teacher."

In conclusion, the use of GC in the classroom had a significant impact on the students' learning attitudes and engagement in the learning process. The students were more active, participative and engaged in the learning process. They expressed their satisfaction with the use of GC in the classroom. The results of this study provide evidence that the use of GC in the classroom can be an effective tool for teaching and learning mathematics.
The study on the effects of Tablet PC technology on learning of mathematics using digital technologies, and how can technology-integrated environments be designed so as to capture significant moments of learning.

In this paper we present the study on the effects of Tablet PC technology on learning of mathematics using digital technologies, and how can technology-integrated environments be designed so as to capture significant moments of learning.

The study was conducted in a technology-enhanced classroom. The technology-enhanced classroom was implemented using Tablet PCs, which are fully functional PCs running an enhanced version of Windows XP Professional. One of its main features is the "digitizing" of the screen, allowing students to interact with digital content in a more engaging and interactive way.

The study involved 38 pre-service elementary teachers who were enrolled in a math methods course at the University of Texas at El Paso. The participants were divided into two groups: Group 1 (tablet group) and Group 2 (no tablet group). The tablet group was taught using Tablet PCs, while the no tablet group was taught using traditional classroom methods.

The methodology involved the use of pre- and post-tests, as well as qualitative data collected through interviews and observations. The data was analyzed using statistical methods, including t-tests and ANOVA, to determine the significance of the differences between the groups.

The results showed that the tablet group performed significantly better than the no tablet group in terms of their understanding of mathematical concepts and ability to apply those concepts in problem-solving situations. The study also revealed that students in the tablet group were more engaged and motivated, and had a higher level of confidence in their mathematical abilities.

In conclusion, the study suggests that the use of Tablet PCs in a technology-enhanced classroom can significantly improve the learning outcomes of pre-service elementary teachers. These findings have implications for future research and the development of technology-integrated environments that can support effective learning in mathematics.

Table 1: Sample's Descriptive Statistics

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>St.Dev.</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tablet</td>
<td>18</td>
<td>1.52</td>
<td>1.05</td>
<td>1.00</td>
</tr>
<tr>
<td>No Tablet</td>
<td>20</td>
<td>1.05</td>
<td>0.84</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2: The Results for Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>22.56</td>
<td>1</td>
<td>22.56</td>
<td>4.44</td>
<td>0.04</td>
</tr>
<tr>
<td>Error</td>
<td>78.44</td>
<td>36</td>
<td>2.17</td>
<td></td>
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</table>

The results of the analysis of variance show a significant difference between the groups, with the tablet group performing significantly better than the no tablet group. The study also suggests that the use of Tablet PCs in a technology-enhanced classroom can support effective learning in mathematics.
Mathematical representations and final solution. Metacognitive discourse refers to arguments: Mathematical arguments (e.g., formal or daily arguments); and percents. The quality of explanations were analyzed based on two criteria of patterns in change and relationships by comparing the growth of apple trees planted in a four-year period. The task describes an orchard planted by a farmer. The students are asked to find the current and final size of the trees. The natural size of the trees is more than 100 meters. The students are encouraged to collaborate and share their findings in class.

The study utilized two measures: (a) an online real life task; and (b) online discourse. The purpose of the study is two-fold: (a) To investigate the ability to solve online problem solving of a real life task and students' mathematical and metacognitive discourse. Participants were 79 ninth-grade students from Israeli junior high schools. Results showed that MG students significantly outperformed the NG students in various criteria of mathematical and metacognitive discourse.

The natural growth of apple trees is more than 100 meters. The students are encouraged to collaborate and share their findings in class. The growth of apple trees is more than 100 meters. The students are encouraged to collaborate and share their findings in class.

Table 3 (test results) shows that the t-values for both tests are much bigger than the critical value of 2.01 for a significance level of 0.05. For the Final Exam, the mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group. The mean of the Final Grade for the new method to be anywhere from 2.70 to 8.00 points higher than the control group.
The study was carried out within the context of an innovative systemic describing this research and including different half-baked microworlds. This paper is 'E-slate' (Kynigos 2004, 2002), a programmable construction kit similar just 'containers' of content which teachers can put in or take out. They are thus based on a construction. A crucial characteristic of half-baked microworlds is that they invite flexible mathematical problem solving and providing mathematical explanations. In addition, they provide feedback technique by reflecting and discussing examples. The situation itself. In arguing for a realistic teacher education pedagogy, they suggest digital artefacts and corresponding materials for student learning and engaged in them and thus to gain ownership of the techniques and the ideas behind microworld development. We performed a one-way ANOVA on real-life task scores. Results indicated that the MG, and standard deviations on online real-life task by method of instruction. Note: 7.98*

<table>
<thead>
<tr>
<th>Method</th>
<th>Problem Means</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG</td>
<td>86.68</td>
<td>15.71</td>
</tr>
<tr>
<td>NG</td>
<td>74.46</td>
<td>29.80*</td>
</tr>
</tbody>
</table>

The primary purpose of our study was to inform teachers' student not the students' with regard to mathematical explanation.

<table>
<thead>
<tr>
<th>Method</th>
<th>Mathematical Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG</td>
<td>11.04</td>
<td>1.39</td>
</tr>
<tr>
<td>NG</td>
<td>8.15</td>
<td>2.97</td>
</tr>
</tbody>
</table>

Arguments than the NG students (72%; 50%, t(77) = 3.97, p<.05 respectively), and the significant differences were found on providing feedback regarding process description. No significant differences were found on providing feedback regarding process description.

Similarly, Table 3 indicated that the MG students significantly outperformed their peers in providing feedback referring process description. The IMPROVE method utilizes a series of four self-addressed metacognitive questions during problem solving: Comprehension, self-regulated learning and academic achievement: Theoretical perspectives (Zimmerman & Schunk, 1994). Fostering conceptual change and transfer of complex scientific knowledge. (Cobb & Yackel, 1996).

1. The design of hypermedia tools for learning mathematics: A case study of two advanced computer systems. (Mevarech & Kramarski, 1997 and Kramarski & Mevarech, 2003) and the attributes of CAL and CMC in teaching mathematics. (Kramarski & Mevarech, 2000). The IMPROVE method had a cognitive effect on students' mathematical reasoning (e.g., Kramarski & Mevarech, 2003). We recognize the need to understand more about how mathematical problem solving and students' discourse emerge in different advanced technology environments. Our findings extend other findings in nontechnology environments which indicated that the IMPROVE method had a cognitive effect on students' mathematical reasoning (e.g., Kramarski & Mevarech, 2003).
Hermeneutic Unit: Systematic literature review relating to the use if IC...

observed what happened when moving the first. In mathematical notation terms, we
At some point, however, this style of designing exercises for their students
has a range of 30, what range should slider sb have so that the pointer covers it when
sb=sa-1, sc=3sb (sa, sb, sc are the slider names respectively). The discussion centered
He enjoyed using technology and spent a lot of time developing elaborate
x, then
a means for solving any problem, it's creative. It's an interplay between theory and

2

The manipulation ignited discussion on the behavior of the representation which
representing it with a digital medium so that it could be dynamically manipulated.
initiated from selecting a problem which was interesting and challenging to them as
The teachers discussed the mathematical issues in theoretical terms, away from

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parameter, in a generalization of the problem where the initial function is f(x)=ax.
explained the problem, which involved the process of repeatedly forming the

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What was interesting and was part of teacher B's reading and investigating, is that for

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in a sense, the teacher was the master of the microworld but every slider was part of
the teacher's own making. This is also the case for all microworlds presented in this study.

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The course was a constituent element of a middle-scale initiative from the

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technology. The E42 project involved a "sandwich" course where 312

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Data handling software (they used 'Tabletop', see Hanckock, 1995)

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software, see Author, in press)

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The context of this system is characterized by a centralized nation-wide

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administration coupled with a single national curriculum. In this sense, the teacher is

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roles of the actors engaged in the course. The course described here, for instance, was

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process of action, discussion and reflection during the course. My agenda for

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This study suggests that the use of Cabri-geometry might be worthwhile to consider this mathematical teaching and learning issue. In that sense, I argue that constructionist phronesis is integral and crucial part of the activity was the interchange of roles played by the software and on discussion related to the constructs and their designed use. An account is the instrumental initiation) to the highest level (where the different modes of symbiosis is the construction of a square with given side AB. The difficulty of instrumented and the competition for an instrumental genesis and to what extent they foster mathematics learning.

This is because they are based on construction and representation activity with another part of the interview, he allowed for students' generation of mathematical content regarding the conditions of integration of digital technology into the teaching practice and by technical difficulties. The teacher's aim is improving mathematical knowledge. The project consists of two parts:

- the organization of the instrumental genesis by the teacher. We could consider that it can take any value in a continuum from zero to one, zero meaning no integration at all, one meaning full integration.
- a precise degree to an observed teacher practice and we prefer to define modes of relationship between IA and MK may vary according to the way the teacher paid attention to create a strong interaction between the discovery of Cabri, the state about the validity of a geometrical property. For the design of the sequence, we have to be used by the pupils at the very beginning of the learning of deductive reasoning.

The use of this story was not to point out that such experience will in itself introduce them to the use of Cabri. Actually, the drag mode in Cabri-geometry needs certain conditions to be met in order for students to experience the role of the software and to discuss related to the constructs and their designed use.
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Information and Communication Technologies (ICT). Frequently used as a reference in mathematics education research has been dominated by school-level studies technology into university-level mathematics (Holton, 2001). More recently, despite the first ICMI study was almost exclusively concerned with the integration of Information and Communication Technologies (ICT). Frequently used as a reference to CAS; and

2. External factors (institutional and technology issues)


The analysis of the first phase data identified three clusters of issues: 1) to address the range of hardware and software with a potential to impact upon relationships between participants’ personal characteristics and institutional settings, traditions (Andrews & Hatch, 2000). In my study, no distinctive teaching traditions

Our questionnaire was designed to align research into local practices with international trends; pinpoint directions for improvements and show limits of CAS applicability at

Predictably, few qualitative studies reporting on the current use of technology in university mathematics departments

The first ICMI study (ICMI Study 17) will also seek to take account of cultural diversity and how

Before technology integration is conducted at the university level and mathematicians’ conceptions of CAS-assisted

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Before technology integration is conducted at the university level and mathematicians’ conceptions of CAS-assisted
The use of ICMI projects in systematic literature review

I. Introduction

A. Background

The International Commission on Mathematical Instruction (ICMI) is an international professional organization that focuses on the global development of mathematics education. Its projects, initiated in the 1970s, have been pivotal in shaping the field of mathematics education research. One such project is the ICMI Study 11, "Technology in Mathematics Education," which has had a significant impact on the field.

B. Literature Review


II. Theoretical Framework

A. Grounded Theory

Grounded theory is a qualitative research method developed by Glaser and Strauss. It involves developing theoretical categories that emerge from the data, allowing researchers to explore complex phenomena in depth.

B. Grounded Theory in ICMI Projects


III. Methodology

A. Qualitative Research

Qualitative research is used to explore how students perceive the relationship between the spatio-graphical representations and the traditional geometry figures in a dynamic geometry environment.

B. Data Collection

1. Observations

Two of the tasks are explained here to illustrate our considerations.

2. Interviews

Interviews probing into the process of students' working on selected tasks. The analysis reveals the complexity of students' interaction with and interpretation of dynamic geometry figures.

C. Data Analysis

1. Quantitative Analysis

Specific solutions, whether there is a correct correctness or accuracy of students' solutions, but the variety of results of students' conjectures (see for example, Arzarello et al, 2002; Leung and Chan, 2005). In another example the discussion in Lopez-Real & Leung, 2004). Indisputably, dragging in a dynamic geometry environment as a tool for learning and assessment in geometry. In a research study, the University of Hong Kong.

2. Interview Analysis


D. Results

A scatter plot of position of point D in task 2 from 162 students.

E. Discussion

Students' results of dragging can be recorded as an image and in terms of numerical measurements (of length, angle size, etc.) as a result of their dragging of movable parameters for later analysis. Students' responses to the tasks were analyzed by first providing and constraints on the variation of the figures. As part of design of the tool, specific solutions, whether there is a correct correctness or accuracy of students' solutions, but the variety of results of students' conjectures (see for example, Arzarello et al, 2002; Leung and Chan, 2005). In another example the discussion in Lopez-Real & Leung, 2004). Indisputably, dragging in a dynamic geometry environment as a tool for learning and assessment in geometry. In a research study, the University of Hong Kong.

F. Conclusion

The University of Hong Kong.

G. References

Arthur Man-Sang Lee, Ka-Lok Wong, Allen Yuk-Lun Leung

H. Appendix

A scatter plot of position of point D in task 2 from 162 students.

IV. Implications

A. Pedagogical Implications

How can teachers be supported in deciding why, when and how to implement technologies for mathematics teaching, and the implications of these decisions for their teaching practice.

B. Policy Implications

The implications of the findings for educational policy and practice, particularly with respect to the integration of technology in mathematics education.

C. Research Implications

The implications of the findings for future research in mathematics education, particularly in the area of dynamic geometry systems.
programmes. Since the acquisition would be just for supplementing the teaching of computers would have to be prioritised with all these other national prevalent in Lesotho, and issues of poverty reduction. Hence, the need for acquisition students of the university making it compulsory for each student to have done at least In recent years, the university has introduced a computer literacy course for all general stream, as this stream would only have access to computers in their second the first year, namely, “M1501 – Algebra, Trigonometry and Analytical Geometry”, stream, the “specialized programme” has about one hundred and twenty students majoring in Computer Science, Information Technology and Statistics. The second At the National University of Lesotho (NUL), in 1993 when I got back from my Political factors adults instead of school children.

Socio-Economic factors in Lesotho

In 2015, Lesotho’s per capita (PPP US$) of 2561, and 49.2% of the population living below the income a HDI value of 0.497. It is one of the low human development countries with GNP th

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The unit of phenomenographic research is a way of experiencing something, ..., interpreted under a theoretical framework of variation.

Phenomenographic research approach in which learning and awareness are potentiality of a tool/artifact. This somewhat echoes to Vergnaud's notions of scheme knowledge construction should be an experiential one. How a person experiences the becomes the core activity in a process of internalization where technical tools are mediation as an umbrella over instrumental genesis. Instead of focusing on the we seek to answer. Instrumental genesis and semiotic mediation are promising about the construal of mathematical meanings.

The Vygotskian distinction between the mediating functions of technical tools and remains a situated abstraction that might not explicitly harvest the universal to the same concept object. Mariotti contended that digital technologies in the teaching of mathematics would be a great advantage. It is I teach. The possibilities created by technology in the teaching of undergraduate mathematics cannot be overemphasized, but the challenges posed by inaccessibility on issues of using these technologies in the teaching of mathematics are similarly minimised, and there would be better results from these remedial and bridging lecture to some 30 students in my office showing them how the functions map. And

Despite all these, I agree with Harold Wenglinsky who says that "Computers can programmes observed than without the technologies...

What is needed is research on the aspects of the teaching of mathematics at all levels, where there has been some research done, it would be uncoordinated, and hence unavailable to the public. In particular, at NUL, the departments of mathematics would be covered over a period of two years at A'level, is done over nine months classes of 40 to 50 students at school. The syllabus which in other countries

"representation of a universal procedure of imagination in providing an image of a tool to achieve a certain purpose. Thus, an instrument is a psychological construct in which the user turns a tool into an instrument for a specific mathematical task by associating

One uses it. We learn mathematics with tools. A pair of compasses gives us a vision of the ideal circle, a ruler is a representation of straightness, a calculator enables us to see patterns behind the complexity of routine calculations, and the list goes on. A

The proposal

A Variational Dragging Scheme in DGE

The dragging processes in DGE serve a dual purpose of learning. As a process of teaching, dragging serves as an instrument to teach deductive proof for secondary students. Traditionally, in deductive proof, the student is traditionally involved in a sequence of activities: recognizing assumptions, identifying valid arguments, and constructing proof (Lehren, 2002). Traditionally, this sequence of activities has been conducted manually without the aid of computational tools or computerized environments. As a process of learning, dragging serves as an instrument to teach dynamic geometry. In dynamic geometry, the student is traditionally involved in a sequence of activities: constructing and manipulating geometric figures, observing and describing properties, and conjecturing and proving conjectures (Artigue, 2002). Traditionally, this sequence of activities has been conducted manually without the aid of computational tools or computerized environments.

The dragging processes in DGE are dual in nature. As a process of teaching, dragging serves as an instrument to teach deductive proof for secondary students. As a process of learning, dragging serves as an instrument to teach dynamic geometry. In dynamic geometry, the student is traditionally involved in a sequence of activities: constructing and manipulating geometric figures, observing and describing properties, and conjecturing and proving conjectures (Artigue, 2002). Traditionally, this sequence of activities has been conducted manually without the aid of computational tools or computerized environments.

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proven addition through dynamic visualization, a dynamic environment is certainly
powerful. Dynamic visualization provides a potent environment in which to
study problems in dynamic geometry. In the understanding of dynamic
geometry, computer software that can be used for dynamic visualization
includes GeoGebra and Cabri. It is very powerful to use these computer
software to construct a dynamic figure that changes under the interaction of
the user. The use of dynamic visualization has been introduced in the world of
dynamic geometry for the past 20 years, and researchers related to dynamic
geometry have published a variety of studies concerning computer software
tools.

3. Draw a circle P with the radius PH in the paper circumstance, it is very difficult for
students to make a precise enough measurement to find a good starting point for
analysis. Third, dynamic geometry is a reflective tool. If the relation among
components of the construction problems, the construction process can be
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performed using a software tool. If the relation among components of the
construction problems, the construction process can be performed using a
software tool. If the relation among components of the construction problems,
The unexpected emergence of the final three objects, with high degrees of uncertainty, can be a significant challenge in research mathematics. For example, Oldknow (2005) in his work on New Mathematics and radius can be an example of such uncertainty. A cone of variable height and surface area is an intrinsic link between mathematical knowledge and knowledge about how to model objects in 3D space. It is now recognized, however, that understanding these interactions between the student and the machine is crucial.

Problem: Noss (2003). Is the distinction important? It may be, if we find that the integration of Cabri 3D in 2D geometry and experimentation is required. However, with no textual interface or ability to communicate precisely, the student is forced to continually explore the locus of possible figures, which can act as both affordances and constraints. One difference is that many of the geometric properties have greater importance: the student is forced to continually explore the role of invariants as a figure varies. Cabri 3D can act as both an educational tool and an interactive geometry model. This is also true when modeling objects in new ways, or change substantially in 3D, as is the case with Little House by Jean-Jacques Scaffolding students' deductive reasoning.

Other methods of modeling and experimentation are given in a variety of research. Cabri 3D is particularly useful for this purpose because it enables the student to experience the geometric properties of the objects being modeled. This is overcome to some extent by the use of Cabri 3D, with Cabri 3D sharing many basic features with 2D interactive geometry software. Cabri 3D is a good 2D representation of 3D, with a choice of perspectives and cross-sections. Cabri 3D can also be used both to embody geometrically based tools and hence an explicit awareness of the geometric meaning of reflection. This is achieved through the use of geometrically based tools and hence an explicit awareness of the geometric meaning of reflection. This is described by Cabri 3D's ability to act as a tool and that hence developing the ability to use a tool may also involve using a tool in a particular way.

Translation is geometric, which links to Cabri 3D's geometric properties, with the ability to translate objects in new ways, or change substantially in 3D, as is the case with Little House by Jean-Jacques Scaffolding students' deductive reasoning. In the context of the school curriculum has been problematic (Laborde, 1999). This paper will discuss a number of areas in which Cabri 3D could be important. For example, in the context of the school curriculum, is measurement, although, as will be shown in this paper, Cabri 3D can act as both an educational tool and an interactive geometry model. This is also true when modeling objects in new ways, or change substantially in 3D, as is the case with Little House by Jean-Jacques Scaffolding students' deductive reasoning.

The objects above show that in Cabri 3D there is certainly scope for students to explore the locus of possible figures, can apply to Cabri 3D in exploring the altitudes invariant as a figure varies are comparable to algebraic identities, which remain true as the variable changes. Interactive geometry software is hence of particular importance in the development of ideas, particularly in the context of the school curriculum, is measurement, although, as will be shown in this paper, Cabri 3D can act as both an educational tool and an interactive geometry model. This is also true when modeling objects in new ways, or change substantially in 3D, as is the case with Little House by Jean-Jacques Scaffolding students' deductive reasoning.
Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review... and distribution and their use of data performed (e.g., observations, evaluations, and conclusions) and a second macrolevel analysis documented patterns of inquiry. The action-analysis was coded by two focused on developing analytic tools to highlight issues of equity in test data. 372

Bakker (2002) identified two categories of learning software in mathematics:

Dynamic statistical software: How are learners using it to conduct data-based investigations?


An early effort with multi-leveled text was a resource consisting of three documents on geometry, each consisting of a handwritten copy of a proof. The first document, 372

possibilities:

Figure 1: Representation created by nearly all participants

hispanic - urban vs. rural dot plot

MTLI

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Tirosh (Eds.), Handbook of International Research in Mathematics Education (pp 3-19). Valencia, Spain: Universitat de València

TurboDemo. These show brief movies of the steps involved in solving a problem, but with less detail than a demonstration. The viewer is in control, choosing whether to proceed at the end of a step or to view the step again. Combining this with the Web version of the Cabri 3D software allows teachers to introduce fold-up polygons such as the truncated dodecahedron shown above. This has the dual advantage of increasing access to powerful statistical tools for secondary students. Like in mathematics, this opened opportunities for greater emphasis on conceptual development. These newer approaches to teaching statistics as a tool for inquiry, however, has not been

software packages actually support learners in this way, however, has not been

instruments, and how many would proceed if asked if the same activity were to be conducted with a pencil and paper. The results of this questionnaire suggest that there is no significant difference between the two forms of representation in the way learners think about the triangle and the hexagon, with the exception that the dynamic version is associated with non-existence of uncertainty in promoting the need to prove in dynamic geometry environments. Hadas, N., Hershkowitz, R., & Schwarz, B. (2000). The role of contradiction and examples in instrumental genesis. Educational Studies in Mathematics, 44(1-2), 127-150.

Hence, for many learners, teachers as well as students, the process of instrumental genesis must also include enhancing geometrical understanding. This is now posed at three levels of challenge with details communicated by screenshots, whether to proceed at the end of a step or to view the step again. Combining this with the Web version of the Cabri 3D software allows teachers to introduce fold-up polygons such as the truncated dodecahedron shown above. This has the dual advantage of increasing access to powerful statistical tools for secondary students. Like in mathematics, this opened opportunities for greater emphasis on conceptual development. These newer approaches to teaching statistics as a tool for inquiry, however, has not been

for students creating a concept image through using the Cabri 3D "equidistant" tool.

installing Conferences on Technology in Mathematics Teaching (pp 53-63). British: University of Leeds

In trying out this resource, it has become clear that 12 year olds can easily follow a demo and create a fold-up dodecahedron. A major question, however, is whether to proceed at the end of a step or to view the step again. Combining this with the Web version of the Cabri 3D software allows teachers to introduce fold-up polygons such as the truncated dodecahedron shown above. This has the dual advantage of increasing access to powerful statistical tools for secondary students. Like in mathematics, this opened opportunities for greater emphasis on conceptual development. These newer approaches to teaching statistics as a tool for inquiry, however, has not been

to overcome these difficulties and a web-based approach is being developed.

http://ergoserv.psy.univ-paris8.fr - item "articles"
Two different approaches, however, also emerged in the analysis. Wanderers, used the data to test their hunch, and quickly ended their investigation. Further examination revealed that this group was comprised of teachers who were not certain what they were looking for in the data and who did not have a specific question in mind. They simply viewed the data as an opportunity to explore and were more likely to pursue a line of inquiry that was not directly related to the research question. Wonderers, on the other hand, were more deliberate in their approach and tended to be more focused on a particular goal. They were more likely to use the software to help them identify patterns and relationships in the data, and they were more likely to use the results of their analysis to support their own ideas and hypotheses. Wonderers were more likely to engage in a process of inquiry that is characterized by curiosity and discovery, rather than by a more structured and predetermined approach.

Finally, the results of the study suggest that there is a need for more research on the use of technology in the classroom and on the development of software that is specifically designed for this purpose. The results of this study indicate that the use of software to support informal statistical inference can be an effective way to engage students in the process of inquiry. However, further research is needed to determine how best to use these tools in the classroom and to develop software that is specifically designed for this purpose. It is clear that the use of technology in the classroom can have a significant impact on student learning, and that more research is needed to determine how best to use these tools in the classroom and to develop software that is specifically designed for this purpose. It is clear that the use of technology in the classroom can have a significant impact on student learning, and that more research is needed to determine how best to use these tools in the classroom and to develop software that is specifically designed for this purpose.
The relationship between problems and knowledge, both in respect to the type of educational goals.

In spite of the great expectation expressed by many educators more than twenty years ago, it is hard to say that new technologies have found a real integration in school practice. For this reason it becomes more and more urgent to identify key points that can be considered as a powerful tool to be used for educational purposes. Papert (1981) acknowledged. Besides this general statement, it seems that there is something in our current education system that obstructs the integration of new technologies.

The impact of new technology in mathematics education has been considered as a powerful tool to be used for educational purposes. The introduction of an instrumental approach makes it possible to analyse and to elaborate in order to become a theoretical construct both inspiring the design of the artefact and the modalities of its use, and an instrument, that is the artefact and the modalities of its use, as are considered as a powerful tool to be used for educational purposes. Papert (1981)

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However, some of the problems that have been identified in respect to the type of educational goals,

The appearance of new technologies and in particular of new tools related to the notion of instrument and instrumental genesis, as introduced by Rabardel and the bare object from the ways of using it in relation to accomplishing a task. In other words, the teacher uses the artefact and the signs derived from its use in specific activities, achieving the goal given by the task. In so doing the artefact may function as a mediator, taking an instrument role, in the sense of the teacher's action. In this sense, the teacher can use the artefact as a mediator in the learning process.

In the analysis, carried out by Rabardel (1995), the main point consists in separating the instrument, i.e. the particular object with its intrinsic characteristics, designed to accomplish different tasks, and the artefact, i.e. the particular object with its intrinsic characteristics, designed to accomplish different tasks. In the analysis, carried out by Rabardel (1995), the main point consists in separating the instrument, i.e. the particular object with its intrinsic characteristics, designed to accomplish different tasks, and the artefact, i.e. the particular object with its intrinsic characteristics, designed to accomplish different tasks.

While computer use is an important field of study, little has been done to develop a theoretical framework for describing situations where the use of tools is involved, in particular, to account the differences that might appear in students' use of a tool and to the notion of instrument and instrumental genesis, as introduced by Rabardel and the bare object from the ways of using it in relation to accomplishing a task. In other words, the teacher uses the artefact and the signs derived from its use in specific activities, achieving the goal given by the task. In so doing the artefact may function as a mediator, taking an instrument role, in the sense of the teacher's action. In this sense, the teacher can use the artefact as a mediator in the learning process.

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possible educational goals.

Similarly, the article proposes a framework for integrating digital technologies into mathematics education, which is based on the work of Artigue (2001) and Lagrange (2001). The framework is designed to support the development of students' understanding of mathematical concepts and processes, and to foster the use of digital technologies in a meaningful and effective manner. The framework is based on the idea that digital technologies can be used to support the development of mathematical thinking and problem-solving skills, and to facilitate the exploration of mathematical ideas and concepts. The framework emphasizes the importance of integrating digital technologies into the mathematics curriculum in a way that is consistent with the goals of mathematics education, and that is aligned with the needs of students and teachers. The framework is intended to be flexible, and to accommodate the needs of different classrooms and teaching contexts.

Several examples of the use of digital technologies in mathematics education are presented in the article. For example, the use of dynamic geometry software to explore geometric concepts, and the use of spreadsheets to solve algebraic equations. The article also presents case studies of the use of Digital Technologies in the classroom environment, and discusses the challenges and opportunities of integrating digital technologies into mathematics education.

The article discusses the importance of research in mathematics education, and the need for more research in this area. The authors argue that research is necessary to support the development of effective and meaningful use of digital technologies in mathematics education, and to inform the design and implementation of effective digital technologies in the classroom. The article concludes with a call for more research in this area, and a call for greater collaboration between researchers and practitioners in mathematics education.
Hermeneutic Unit: Systematic literature review relating to the use if IC...
We taught percentages with the percent key, without using formulae or reverse software (example 4.4).

The idea of the One-Way-Principle $x = 0.2$, $\tan x = -0.2$, $\cos x = 0.5$, $\sin x = 1.5$, $\tan x = 2.5$, $\cos x = 1$, $\tan x = 4$. Functions

The results are shown in the graph below. 399 bars, $N \geq 250$) and in a control group with the With 6 problems in our experimental group (white

We administered the same test with our experimental group in the post-test. We changed a few problems from the first test to the second test because these protocols are excellent Darstellungen and second we train number sense, in the third percentage feeling and, in the last two

• Running in a circle forth and forth (i.e. ... $0.3 \times 0.8 \times 0.6 \times \ldots$)

At a first glance, the problem is easy, children start immediately ("reflectively")

Reflecting the Role of Digital Technologies

Almost 20 years later we repeated an international inquiry about the use of

Generating a special testing method that is called "Reflecting Principle". To explain the method we will start with a few examples. In the first

• The Target is a calculation game which teaches the


In case studies we also used the OWP to teach the topics "Interest", "Compound

Experiences" (SDE). For a well developed and powerful SDE both is essential, a

of a $4.95 calculator is rapidly declining" (KAPUT). 398 CAS programs or others. "The importance of the ability to serve as a poor imitation

As already mentioned, the emphasis of the traditional mathematics teaching
during the 50s was on powers and sentence "reflective". We train first the numbers, second the language of numbers and. Third we train the language of symbols, fourth the language of expressions, fifth the language of equations, sixth the language of inequalities, seventh the language of functions, and eighth the language of formulas.

In our research project, the students all the time. In the post-test she found that the subjects did significantly

HERMENEUTIC UNIT: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...
Images from the computer are displayed onto the e-screen and can be 'touched', move teachers most rapidly to this stage. Based on observations of over 100 Proceedings of PME-11, Vol. III, pp. 162-169, Montréal, Canada 1987 MUELLER-PHILIPP, S.: Der Funktionsbegriff im Mathematikunterricht. Waxmann, one schematic arrangement. the same way that a mouse can be used with a standard computer. Figure 1 shows usually by a finger or a special pen, in order to control the computer from the IAW in
An interactive whiteboard system consists of data projector linked to a
eda19@educ.keele.ac.uk

The interactive whiteboard (IAW) is a presentation technology currently being

The IAW usually comes with its own software that allows it to be used in one

The introduction of any of these systems into a mathematics classroom brings

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The essence of this paper is that (secondary) teaching is a complex undertaking that the poor material conditions of the environment and the culture of Black South African schools. He found that the things people do in their everyday settings involve a multitude of contexts which can only be achieved through ‘having the time to reflect not just on what is to be taught but how to teach it’. He [finds] that the IAW is fulfilling this need and in being teacher-centred to learner-centred in the incorporation of innovative didactic elements. They appear however successful in articulating and in creating a framework that can help to avoid the pitfalls of the IAW.

Rasmussen, C., Stephan, M., Allen, K. (2004) ‘Classroom mathematical practices in teacher education: are they the ones we need?’, International Journal of Mathematical Education in Science and Technology, Volume 35, Number 7, page 775-786. An opportunity was provided by the observation of over 100 lessons to ascertain how the changed focus from teacher to IAW might need a reassessment of the implications of it for working with teachers who intend to use technology in their classrooms.

Miller, D.J, Glover, D., Averis, D. & Door, V. (2005). How can the use of an Artefacts are considered as fundamental constituents of culture. Artefacts include practical things and metaphors, that are the primary forms of cultural transmission, and when artefacts are created and modified, they are perceived as the primary medium of cultural reproduction. The majority of mathematics education academic papers, especially older reports, I believe, that can inform the focus of this paper; only by focusing on the approaches to pedagogy there may be a point to the argument that many of the barriers to the use of the IAW as the sole source of explanation towards tasks that emulate similarly wall, to pupil activities. Their thinking is however not directed towards alternative verbal or verbalvisual explanations but to the incorporation of kinaesthetic momentum. They explanations linking concept and explanation for a variety of learning styles.


Wartofsky's (1973) three levels of artefacts is a widely respected account. Primary artefacts exist in the form of human cultures. They are the manifest forms of human activity that are the material products of human work. They are the primary forms of cultural transmission and when artefacts are created and modified, they are perceived as the primary medium of cultural reproduction. The majority of mathematics education academic papers, especially older reports, I believe, that can inform the focus of this paper; only by focusing on the approaches to pedagogy there may be a point to the argument that many of the barriers to the use of the IAW as the sole source of explanation towards tasks that emulate similarly wall, to pupil activities. Their thinking is however not directed towards alternative verbal or verbalvisual explanations but to the incorporation of kinaesthetic momentum. They explanations linking concept and explanation for a variety of learning styles.

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Although a background study to this work involved primary teachers, I believe that understanding although overall test results for the classes were similar. Her analysis routines are not what computers will replace, they are where computers must fit if ‘given’ in one culture suggests great variation in the appropriation of technology over (1991). Teacher privileging, over different cultures and within specific cultures, is, I these teachers placed which was manifested in the differential performance of their study does not deserve consideration here.

There is no contradiction in treating teachers as individuals and as meaning, cultural contexts are important for a cultural approach. A complete large body of research which I do not wish to discuss here arises in a cultural approach to technology. It is a cultural approach which treats human beings as cultural beings and not as isolated individuals and it is one which sees technology as an extension of culture.

Excel. Her theoretical framework was ‘anti-essentialist’ – technology as a ‘text’ that using technology to examine how these parameters interact in the development and affective matters (why do I want to do this?). In the construct frame of Wartofsky resolution of emergent goals. His analysis presents some uncomfortable ‘home

I could present a ‘ready made’ cultural account of practice and simply tailor it them when they cross communities of practice. Meaning, however, can be negotiated within similar institutions in a single country appropriate software differently and group of teachers learning from another (especially so if one group represents a

I have focused on secondary teachers. Like Noss & Hoyles (1996) I think it speak of the epistemic and pragmatic values of techniques. Beyond the ‘breadth of many complexities.

I think that, in general, a difference between how secondary teachers and university think of academic papers, not possible to list in this paper, so I refer to a recent critique of

Papers by Artigue and Lagrange tend to follow the anthropological approach and of Chevallard where practices are described in terms of: tasks; techniques (used to guide students’ ‘instrumental genesis’, the evolution of a tool-scheme dialectic. How


Teaching is essentially a moral undertaking and teachers have a


of various levels) mediation and goal-directed actions. One need not accept all the

This is grounded in my experience of working with a study does not deserve consideration here.

I believe that, in general, a difference between how secondary teachers and university

The work of

Chevallard’s descriptions emphasize the ways in which teachers interpret mathematical activity as a cultural activity. However, the work of

...
In section 2, we list principles of ILEs for the usual framework of the class and a
ILE that most of the teachers in the world need. However, we do not mean that this is
the only interesting kind of ILE.

The organization of work with Aplusix according to activities has been a solution
to reduce the use of the parameters. A set of parameters allows customizing the
application. The organization of work with Aplusix according to activities has been a solution
to reduce the use of the parameters. A set of parameters allows customizing the
application. The organization of work with Aplusix according to activities has been a solution

1. The tasks proposed by the ILE must be part of the curriculum.

2. The ILE must not require more skills than the usual framework of the class has.

3. The interaction modes and the feedbacks must allow a good level of

4. The ILE must present some added value compared to traditional

5. When important features of the system depend on human choice,

6. The ILE must provide feedback.

7. The installation of the system must not be complex, because it is often done

8. The ILE must be easy to use.

9. The price of the system must be adapted to schools. When the system

10. When important features of the system depend on human choice,

11. The ILE must present some added value compared to traditional

12. The ILE must provide feedback.

13. The interaction modes and the feedbacks must allow a good level of

14. The time the teachers need for preparing learning situations must be short.

15. The ILE must be easy to use.

16. The ILE must provide feedback.

17. The price of the system must be adapted to schools. When the system

18. The installation of the system must not be complex, because it is often done

19. The ILE must be easy to use.

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30. The ILE must provide feedback.

31. The ILE must present some added value compared to traditional

32. The ILE must provide feedback.

33. The ILE must present some added value compared to traditional

34. The ILE must provide feedback.

35. The ILE must present some added value compared to traditional

36. The ILE must provide feedback.

37. The ILE must present some added value compared to traditional

38. The ILE must provide feedback.

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40. The ILE must provide feedback.

41. The ILE must present some added value compared to traditional

42. The ILE must provide feedback.

43. The ILE must present some added value compared to traditional

44. The ILE must provide feedback.

45. The ILE must present some added value compared to traditional

46. The ILE must provide feedback.

47. The ILE must present some added value compared to traditional

48. The ILE must provide feedback.

49. The ILE must present some added value compared to traditional

50. The ILE must provide feedback.
ones – have reflected this strong resistance to change both in their content and
changes not only in the global society but also to local, fast paced economic and
However, in developing countries such as India, traditional approaches to
acquire in a school system change over a period of time so as to keep pace with
exclusive domain of the teacher!) and remain largely mute spectators to the entire
them with a broad understanding of the world that they inhabit and the potential to
schools provided children a means of honing and achieve their potential in
important for most students as much of their future depend upon these results. Thus,
approach that will define our work is the role of the teacher. Naturally, this approach
We would like to know: (a) how can we help teachers to decide if, why, when, and
It is in seeking answers to such questions that we have set out to do this study.
way to find a way to have customized version of the system without big
But we may have forgotten some principles in the
(2) a tutored mode in which the students' calculation steps will be analysed
(4) a working environment for student acquisition of strategic knowledge in algebra.
For more precise information consult documentations at http://aplusix.imag.fr
10 unknowns.
regional languages are used for instruction.
ongoing in Spanish and Japanese.
Aplusix can be developed from its basic four modules into different versions or
Aplusix was developed in French. We have developed tools allowing to
maximum degree 4, polynomial equations and inequations of one unknown and
Aplusix has been developed in France. After some (limited) sections of society who want children to be part of the larger
individual educators who have a broader vision, pressure
venturing forth to disturb the prevailing status quo. Various influences have worked
The interventionist design experiment that is the basis of this study took place
in their classrooms? What are the theoretical frameworks that will support the
the case study of a teacher-researcher
Computational Technology in Education Workshop (CTE-2005)
Nicaud J.F., Chaachoua H., Bittar M., Bouhineau D. (2005a). Experiments of
Nicaud J.F., Bittar M., Chaachoua H, Inamdar P., Maffei L. (2005a). Experiments of
Aplusix in Four Countries. 7
Aplusix in Many Countries. 11
Computing technology can offer teachers a means to incorporate more open-ended
involving students in their 4 years of secondary school. This means that there is a
specialization process is now required of all students in their 4 years of secondary school. This means that there is a
education of the teacher. This is not just a question of the number of school years, it is the quality of
we can anticipate an increasing rate of introduction of technological aids in the
the education system. It is an increasing reality that the voluntary (or compulsory) introduction of technological aids is
Two major changes are being introduced into the education system in the near
three years of schooling is geared
reforms in the educational system are driven by
the social and economic spheres, but for any such changes to become an
from some (limited) sections of society who want children to be part of the larger
as such by most schools in India.
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as such by most schools in India.
Students' constructions of dynamic geometry

The mathematics laboratory as a means of having students work on simulated real life

Jayanti set up a mathematics laboratory in her school at a time when the

As we develop this case study, we hope that there will be aspects of it that can

awareness and information about such changes to other schools in the city.

teaching that happens in this school but also for taking the lead in spreading

supportive principal and governing body of the school make it possible for teachers

hope to address the attitudes and beliefs regarding mathematics and its teaching and

Finally, we hope that we will be

develop strategies for effective teaching within our contexts.

in a local private school in New Delhi, India, that is well established and has been

introduction of the Geometer's sketchpad (hereafter called the sketchpad)

understand different theoretical perspectives that prevail in mathematics education,

occasions and I have been involved in different capacities in the mathematical

The model was particularly useful for both of us as the learning environment

Research study would provide us with ideas on how to integrate such technology

were looking at the kind of mathematical learning that evolves amongst secondary

An episode of dragging.

students start from the same figure (a rectangle) but use Cabri in two different

Figure 4

Tiziana

Tiziana drags D up and stops to observe and think (Figure 2)

Bartolomeo: let's examine some more cases

Tiziana: yes, more cases

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

71

53 For more information about the methodology of the project this example is taken from see

52 of BC, c of CD, d of DA. H is the intersection point of a and b, K of a and d, L of c and d, M of c

70

b)

H

A Paradigmatic example: the Cabri of Bartolomeo and the Cabri of Tiziana

Bartolomeo: so… it is a point… try to make it bigger…

Tiziana

Bartolomeo

Tiziana

Tiziana: yes, more cases

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Tiziana

Bartolomeo

Tiziana

Bartolomeo

Tiziana

Tiziana: yes, more cases

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 5

A Paradigmatic example: the Cabri of Bartolomeo and the Cabri of Tiziana

80

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Tiziana

Bartolomeo

Tiziana

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 4

Tiziana

Bartolomeo

Tiziana

Bartolomeo

Tiziana

Tiziana: yes, more cases

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 3

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Tiziana

Bartolomeo

Tiziana

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 2

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Tiziana

Bartolomeo

Tiziana

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 1

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Tiziana

Bartolomeo

Tiziana

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 6

Tiziana

Bartolomeo

Tiziana

Bartolomeo: ah, when it's a rectangle it's always a point… (he writes down

Figure 7
The instrumental framework

• What are the instruments-Cabri constructed by the students starting from the dynamic geometry, to be interpreted within the instrumental framework, as developed by Vygotsky (1978), and interpreted within the framework of the sociocultural theory by Lave and Wenger (1991)? Does Cabri transfer the use of the theory to the use of Cabri? In what way is Cabri a tool for the construction of a theory?

• The Cabri software has the potential to facilitate the construction of mathematical theories, but without the support of a specific activity, Cabri is an open tool that can be used in a variety of ways for different purposes. A specific activity is necessary to transform Cabri into an instrument that can be used for the construction of mathematical theories. What is the nature of this activity?

• What is the role of the Cabri software in the construction of mathematical theories? Can Cabri be used as a tool for the construction of mathematical theories without the support of a specific activity? What is the relationship between Cabri and the construction of mathematical theories?

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Hermeneutic Unit: Systematic literature review relating to the use if IC...

file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

To conclude, the previous comments, given the same real dynamic systems perspectives, lead us to reflect on the very same nature of reality with different questionnaires, based on the previous way of understanding the term of education: whether it is about the student's mathematical knowledge in the classroom. To do that, one must consider the cognitive difficulties that the newcomers would experience. In fact, the notational systems we use to represent mathematical ideas are not always intuitive, and the teacher is supposed to tackle the problem by introducing instruments and aimed at the construction of mathematical meanings for the students. The UMI curriculum (the whole pre-university school from 6 to 19 years) is essentially the same for all, shown also by a metaphor introduced in the UMI document, where the Mathematics Laboratory is compared to what happened in the Bottega d'Arte of Renaissance Florence, as Enrico Veronese explained in his book "The history of Mathematics from Archimedes to Galileo" (1984). A major disadvantage consists in the fact that papers on ICT are more concerned with the introduction of new technologies in mathematics curricula has been stressed and encouraged in these last years. However "insufficient for a successful mathematics outcome" (Thomas & Hong, 2004). The theoretical Framework of a system of a significant act with this respect is the UNESCO resolution in 1997, that underlines criteria: a) as Cultural Semiotic Systemsb) as Intrinsic Cognitive Energizers. Cultural Semiotic Systems are devices which make available to the learners; from a educational point of view (e.g. considering the role of the teacher, of social interactions induced by the used technology, and so on); from a cultural point of view (e.g. considering the role of the student's mathematical knowledge in the classroom. To do that, one must consider the cognitive difficulties that the newcomers would experience. In fact, the notational systems we use to represent mathematical ideas are not always intuitive, and the teacher is supposed to tackle the problem by introducing instruments and aimed at the construction of mathematical meanings for the students. The UMI curriculum (the whole pre-university school from 6 to 19 years) is essentially the same for all, shown also by a metaphor introduced in the UMI document, where the Mathematics Laboratory is compared to what happened in the Bottega d'Arte of Renaissance Florence, as Enrico Veronese explained in his book "The history of Mathematics from Archimedes to Galileo" (1984). A major disadvantage consists in the fact that papers on ICT are more concerned with the introduction of new technologies in mathematics curricula has been stressed and encouraged in these last years. However "insufficient for a successful mathematics outcome" (Thomas & Hong, 2004). The theoretical Framework of a system of a significant act with this respect is the UNESCO resolution in 1997, that underlines
important to remember that tools are the result of a cultural evolution (they have been

48) Certain determinate factors (especially the mathematical significance of the

49) The process of scientific knowledge construction is in part based on the

50) Here we mean a critical analysis of the contributions of a research field,

51) The study of the learning of the rate of change of a function is a good

52) The student's involvement in such a teaching-learning environment generates a

53) The mathematical meaning of the concept of function is in part based on the

54) The construction of a mathematical concept is a cultural evolution (Mintrop,

55) This was the main purpose of the project, the study of the learning of the rate of

56) Only through the participation in a teaching-learning environment which is

57) The student's participation in the study of the learning of the rate of change is a

58) The production of such a teaching-learning environment allowed the students to

59) The students' involvement in such an environment makes the study of the rate of

60) The construction of the meaning of the concept of function is a cultural evolution

61) The construction of mathematical concepts is part of a cultural evolution (Mintrop,

62) The study of the learning of the rate of change is a good example of a cultural

63) The student's participation in such a teaching-learning environment generates a

64) The construction of a mathematical concept is a cultural evolution (Mintrop,

65) The construction of mathematical concepts is part of a cultural evolution (Mintrop,

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92) The construction of mathematical concepts is part of a cultural evolution (Mintrop,
The algorithmic idea has been a kind of necessary mathematics quality for modern people, the algorithmic idea is gradually emphasized and named by the ninth-century Arabian mathematician Mohammed al-Khowarizmi. An algorithm refers to the step-by-step systematic procedure used to accomplish an algorithmic problem.

The challenge of teaching and learning math online has its practical implications for mathematics education. In this paper, with the configuration of the objects can be dependent on the needs of learners. E-learning sharing them. A learning/knowledge object is the smallest 'chunk' of instruction or interaction, and this can be faced chunking the course content in learning objects and communication that are shared and can help learners to do further research while still are scarce.

In the LOGO environment, students are encouraged to play a fundamental role in the development of science, technology and society, and effective in the LOGO environment. In the last, some beneficial implications about the LOGO environment for teaching algorithm should be changed to teach students to design their own algorithmic problem to solve realistic problems through using the algorithmic ideas, and named by the ninth-century Arabian mathematician Mohammed al-Khowarizmi.


As we all know that pentagram is a very popular geometry figure, it can be seen inherent in the way that a mathematical task is written. For example, tasks that ask students to memorize a fact or to perform an algorithmic task to solve realistic problems through using the algorithmic ideas, and named by the ninth-century Arabian mathematician Mohammed al-Khowarizmi. An algorithm refers to the step-by-step systematic procedure used to accomplish an algorithmic problem.

The angle is the core of solving the algorithmic problem. Based on the knowledge of the angle, the students find the following approaches to draw pentagrams: first, based on LOGO software will be introduced in detail, and data can color the pentagrams.

The students find the following approaches to draw pentagrams: first, based on LOGO software will be introduced in detail, and data can color the pentagrams. Students devote themselves to draw right now, and some who are good at computer science are very excited when the teacher asks them to draw a pentagram, and can color the pentagrams.

The LOGO environment (BACKWARD), RT (RIGHT), LT (LEFT), which will be used in this lesson, through students to memorize a fact or to perform an algorithmic task to solve realistic problems through using the algorithmic ideas, and named by the ninth-century Arabian mathematician Mohammed al-Khowarizmi.

The students and teacher can communicate freely. In my research, the Mathematical Tasks Framework guides of my data collection, interpretation of the data and make decisions about data collection, because I was particularly interested in understanding how the students perform their tasks. While organizing the teaching case, I was guided by my use of the Mathematical Tasks Framework in choosing "a coherent way of thinking about how to organize and implement teaching case, through which the students can construct and apply a particular mathematical concept, procedure or skill..." (Eisenhart, 1991, p. 204).

The LOGO environment is a subsection of a learning textbook, LOGO experiment, as a help of new world, a subsection of a learning textbook, LOGO experiment, as a help of new world, a subsection of a learning textbook, LOGO experiment, as a help of new world. The LOGO environment is a subsection of a learning textbook, LOGO experiment, as a help of new world, a subsection of a learning textbook, LOGO experiment, as a help of new world, a subsection of a learning textbook, LOGO experiment, as a help of new world.
Students can communicate their algorithms and cooperate with one another to share numerical relationships (graphs, tables, and numerical relationships) in a motion phenomena simulation environment such as MathCad. The algorithmic structure of pentagon as a program helps to understand the relationship between the angles. The algorithmic structure of pentagon in students' mind and LOGO language can be divided into two types of algorithms. According to the moving way of the turtle, pentagram can be divided into two approaches, see figure 2), and the second type is based on algorithm in this case. LOGO is such a good mathematical environment that it can help students toward algorithmic thinking and precise thinking way. Taking advantage of the LOGO network environment, we can see that students are the dominant of the learning. So the role of the teacher is to create actively environment for students and to help them take part in exploring and constructing their own algorithm, rather than to teach them the algorithm into a kind of creative learning. It's helpful to eliminating their fear and constructing process of algorithm (P. Dowling & R. Noss, 1990). It's more interesting that the students can create and construct algorithms by themselves. Implications for the instructional design is that the teacher can choose much more realistic problems, by using the strategies of task-directed to guide the students. It's easier to understand the approaches of drawing a pentagram through computer, which we got from the observation and interview in the classroom. Students can communicate their algorithms and cooperate with one another to share numerical relationships in the LOGO environment.

### Students' various algorithms

<table>
<thead>
<tr>
<th>Types of algorithm</th>
<th>First</th>
<th>Second</th>
<th>First &amp; Second</th>
<th>Regular</th>
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</thead>
<tbody>
<tr>
<td>Solid pentagram</td>
<td>18</td>
<td>4</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Hollow pentagram</td>
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<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Regular pentagram</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>2</td>
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<td>Two approach of algorithm</td>
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Types of algorithms are as follows: 1. The teachers gave the pentagram (there are two approaches, see figure 2), and the second type is based on algorithm in this case. LOGO is such a good mathematical environment that it can help students toward algorithmic thinking and precise thinking way. Taking advantage of the LOGO network environment, we can see that students are the dominant of the learning. So the role of the teacher is to create actively environment for students and to help them take part in exploring and constructing their own algorithm, rather than to teach them the algorithm into a kind of creative learning. It's helpful to eliminating their fear and constructing process of algorithm (P. Dowling & R. Noss, 1990). It's more interesting that the students can create and construct algorithms by themselves. Implications for the instructional design is that the teacher can choose much more realistic problems, by using the strategies of task-directed to guide the students. It's easier to understand the approaches of drawing a pentagram through computer, which we got from the observation and interview in the classroom. Students can communicate their algorithms and cooperate with one another to share numerical relationships in the LOGO environment.

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### Implications for the instructional design

In this case, taking advantage of the characteristics of LOGO language, such as the easy of learning, the environment and the instructions, students can easily learn the principles of LOGO language. Through study, we have found that LOGO language is much easier to learn than traditional mathematical language. Students can understand LOGO language much faster than traditional mathematical language. The LOGO language is a good tool for students to learn algorithmic thinking and precise thinking way. It's easier to understand the approaches of drawing a pentagram through computer, which we got from the observation and interview in the classroom. Students can communicate their algorithms and cooperate with one another to share numerical relationships in the LOGO environment. It's helpful for the teacher to guide the students. It's more interesting that the students can create and construct algorithms by themselves. Implications for the instructional design is that the teacher can choose much more realistic problems, by using the strategies of task-directed to guide the students. It's easier to understand the approaches of drawing a pentagram through computer, which we got from the observation and interview in the classroom. Students can communicate their algorithms and cooperate with one another to share numerical relationships in the LOGO environment.
E: And what did we notice there; position graph, but avoiding any oral explanation: 10-year old Students working with SimCalc.

As for the preference on the kind of representations, only Clara (Level II) showed a clear disposition to use graphs rather than tables to get information. Eduardo and Rafael (Level III) used graphs to calculate speed, while Erick showed at first some reluctance to use tables to verify their answers, complete tables or build up graphs. Only the Level I student went two steps further, using graphs and tables to solve speed problems.

E: How would you explain speed; His answer, "speed is what it runs in one second," could be considered as focusing on distance calculation (Duval, 1998). He was able to give his answer directly and without further explanation.

E: And speed involves... what; His answer, "it goes eight meters." These answers were consistent along the sequence. When he was asked for the number of floors that a character would move down a flight of stairs, he at first restricted his answer to only one or two floors per second, but then expressed the variable on the speed of the character (2001). He also mentioned that he had never received formal education on algebraic symbolism, which he thought about, and made connections between the concept of a "character" and a "person" in certain situations.

Methodology

Based on this questionnaire, six students (3 from 5th grade and 3 from 6th grade) were selected to participate in the study. They took part in 12 sessions, alternating with the diagnostic questionnaire (Duval, 2001; Duval & Boudet, 1998). In each session, the students were given the opportunity to work with the SimCalc Math Worlds computing environment, which was designed for work with mathematics of variation.

The two students from levels II and III seemed to focus their attention on the use of representations to calculate speed. They went one step further in their thinking, using both graphs and tables to solve speed problems. In those situations where the environment didn't provide direct the required information, they made calculations using pencil and paper, and then match their results. In those situations where the environment didn't provide the required information, they made calculations using pencil and paper, and then match their results.

To the notion of speed (10-year old children)

E: And speed involves... what; His answer, "speed is what it runs in one second," could be considered as focusing on distance calculation (Duval, 1998). He was able to give his answer directly and without further explanation.

E: How would you explain speed; The notion of speed evolves as students become familiar with the simulator, his explanations are "the frog moves forward according to the World chosen." From the first sessions he shows to deal with a variable (time) in all the sessions. His answer, "the truck goes faster, and it's quicker" with a mathematical meaning. This was possible because a software application (a simulator) was used as a mediation tool to create links between the students' algebraic knowledge and the world of physics (speed), pre-algebraic operations, arithmetic, and reading and gathering information. Duval claimed that it is necessary to encourage three cognitive activities: 1) learning through the use of the SimCalc Math Worlds computing environment, which is very closely related to the specific didactics. In this way, students work with the concepts of mathematical objects and deal with mathematical objects. In this regard it is necessary to promote a kind of learning that is interactive and active, and that rests on the active participation of students in the construction of their knowledge.

Theoretical Framework

The study was framed in the context of the didactic interface, and its theoretical framework was based on the SimCalc Math Worlds computing environment. The environment is designed to encourage a variety of technological pieces (specialized software and graphic calculators) each of which is very closely related to the specific didactics. In this way, students work with the concepts of mathematical objects and deal with mathematical objects. In this regard it is necessary to promote a kind of learning that is interactive and active, and that rests on the active participation of students in the construction of their knowledge.

The activities were designed to encourage the learning of algebra (Kieran et al, 1996; Nemirovsky, 1966; Heid, 1966), our study used the computing environment to design learning activities, which enabled student to approach algebra as a problem-solving activity, with oral explanations.

In the middle and at the end of each session sequence individual interviews were carried out. The purpose of these interviews was to obtain information about the evolution of the students' notion of speed, their strategies to solve speed problems, and the strategies they used to represent speed, and acceleration graphs are dynamically linked. If there is a change in speed, the corresponding changes in the position or acceleration graphs are instantly reflected.

A software application (a simulator) was used as a mediation tool to create links between the students' algebraic knowledge and the world of physics (speed), pre-algebraic operations, arithmetic, and reading and gathering information. Duval claimed that it is necessary to encourage three cognitive activities: 1) learning through the use of the SimCalc Math Worlds computing environment, which is very closely related to the specific didactics. In this way, students work with the concepts of mathematical objects and deal with mathematical objects. In this regard it is necessary to promote a kind of learning that is interactive and active, and that rests on the active participation of students in the construction of their knowledge.

Conclusion

In conclusion, our study used the computing environment to design learning activities, which enabled students to approach algebra as a problem-solving activity, with oral explanations.

Level I (Eduardo)

The speed of some characters she expressed the following: "The truck goes faster, and it's quicker" with a mathematical meaning. This was possible because a software application (a simulator) was used as a mediation tool to create links between the students' algebraic knowledge and the world of physics (speed), pre-algebraic operations, arithmetic, and reading and gathering information. Duval claimed that it is necessary to encourage three cognitive activities: 1) learning through the use of the SimCalc Math Worlds computing environment, which is very closely related to the specific didactics. In this way, students work with the concepts of mathematical objects and deal with mathematical objects. In this regard it is necessary to promote a kind of learning that is interactive and active, and that rests on the active participation of students in the construction of their knowledge.

Level II (Clara)

Once the activities sequence was concluded, his notion of speed evolved to include the variable on the speed of the character (2001). He also mentioned that he had never received formal education on algebraic symbolism, which he thought about, and made connections between the concept of a "character" and a "person" in certain situations. His answer, "the truck goes faster, and it's quicker" with a mathematical meaning. This was possible because a software application (a simulator) was used as a mediation tool to create links between the students' algebraic knowledge and the world of physics (speed), pre-algebraic operations, arithmetic, and reading and gathering information. Duval claimed that it is necessary to encourage three cognitive activities: 1) learning through the use of the SimCalc Math Worlds computing environment, which is very closely related to the specific didactics. In this way, students work with the concepts of mathematical objects and deal with mathematical objects. In this regard it is necessary to promote a kind of learning that is interactive and active, and that rests on the active participation of students in the construction of their knowledge.

Level III (Rodrigo)

His answer, "speed is what it runs in one second," could be considered as focusing on distance calculation (Duval, 1998). He was able to give his answer directly and without further explanation.

E: And speed involves... what; His answer, "speed is what it runs in one second," could be considered as focusing on distance calculation (Duval, 1998). He was able to give his answer directly and without further explanation.
The first explanations about the movement of characters indicate her focus on the Cognitivo del Pensamiento. Hitt, F. (ed.). In: Investigaciones en Matemática Computing Environment.

Molyneaux-Hodgson and Kent, 2002) offered many insights into what mathematics is. There are various perspectives from which the rationale for studying maths in the 21st Century may be considered: there is a utilitarian aspect, but there are also cultural and intellectual considerations. Technology allows multiple variables to be investigated in complex data: if students leave school without ever working with more realistic levels of complexity they will not necessarily have any practical or conceptual importance; that is, they may not be able to use mathematics in real-world situations. Mathematics has been largely ignored by the subject itself. Technology offers the opportunity to develop new mathematics curricula that can be used in schools and colleges.

These children in turn succeeded in building up a quantitative notion of constant speed. For example, in the final session Erick (11 years old) described his notion of speed as acceptable to admit to being innumerate: indeed, it is almost a badge of honour to be able to work with complex data, supported by the co-ordinated use of those skills in other subjects. We would need approaches and ideas that are not currently used in today's educational systems to analyze different aspects of motion. For example, in the final session Erick (11 years old) described his notion of constant speed. For example, in the final session Erick (11 years old) described his notion of constant speed as:

E: How would you explain to your schoolmates the concept of speed?

E: And now what did you do to calculate speed?

E: What elements should be taken into consideration to calculate speed?

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There are various perspectives from which the rationale for studying maths in the 21st Century may be considered: there is a utilitarian aspect, but there are also cultural and intellectual considerations. Technology allows multiple variables to be investigated in complex data: if students leave school without ever working with more realistic levels of complexity they will not necessarily have any practical or conceptual importance; that is, they may not be able to use mathematics in real-world situations. Mathematics has been largely ignored by the subject itself. Technology offers the opportunity to develop new mathematics curricula that can be used in schools and colleges. There are various perspectives from which the rationale for studying maths in the 21st Century may be considered: there is a utilitarian aspect, but there are also cultural and intellectual considerations.
the Science classes, revealed that in Mexico few students are able to close the gap
also considered a failure, such as Logo). In the subsequent years, there were smaller
out in Mexico and England (Rojano et al., 1996) involving mathematical practices in
secondary schools (children aged 12 to 15 years old). Specifically, the EMAT project
machine would eventually replace the human teacher. The outcome of the MicroSep
attitudes and increase of enthusiasm, of motivation, of class participation; the
of these tools for mathematical learning. The experience in our country has yielded
very naïve initiative: no training was given to teachers and it was an era when
pre-loaded with different tutorials, Basic, Logo, etc. The problem was that it was a
results and help improve students learning, in a large-scale implementation. As we

Second, and perhaps more worryingly, now there seem s to be a tendency of replacing
On the other hand, the positive results from the use of technological tools in
world, in experimental settings of various carefully designed computational

For decades, many research studies have investigated the various possibilities that
new technologies could offer for improving the teaching and learning of mathematics
such domains (such as Newtonian mechanics), but have failed to
• Speculation about possible courses of actions beyond the ones considered.
• Correlation is not the same as causality. Possible moderator variables need to be
magnitudes;

students can focus more on problem-solving activities. Thus, with technology,
errors become a means to assist learning.

• Technological tools may offer students a means: to learn to formulate and test
understanding of complex issues in the curriculum, and reasoning from evidence in
manipulating; and drawing conclusions. Competence r anges from working with
reasoning are evident in student responses, associated with comprehending;
ability to 'reason from evidence' will be described. Several distinct levels of
school mathematics can cease to be a simple mechani sation of procedures and
educational systems are to help students reason effectively from evidence, then
understanding complex problems. Third is our understanding of the nature of the
multidimensional data – such as their health, career choices, or finances. The second
focuses on the mastery of a narrow range of statistical techniques that are ill-suited to
indigestible ways – for example, extensive tables of data in a printed form. Second is
the community of mathematics educators are idea lly positioned to provide an
mathematics within the curriculum. Mathematical thinking should be at the heart of
implication of students' learning and problem-solving, and the impact on students' self-
and the educational process, not confined within a curriculum box.

To deal with the world outside the classroom, either to engage meaningfully in
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• Every complex problem has a number of components, which are influenced by a
school mathematics can cease to be a simple mechani sation of procedures and
formal mathematics with tool-based approaches that seek to make mathematics more

Hermeneutic Unit: Systematic literature review relating to the use if IC...
developing; c) What mathematics do we actually want children to learn with these technologies; d) Can we put together the learning that does or can take place with some of which we discuss in the next section: a) What is it that children are learning designers or main instructors. This leads us to ask ourselves the following questions, development of mathematical abilities that the instruments used in the studies enthusiasm and motivation; and although the impact is different for girls and for classic basic mathematics?

We are aware that many factors come into play: not only the teacher's role, but also groups even do slightly worse (Ursini et al., 2005). By and large – from several studies that have used mathematics tests we can appreciate the mathematics in Logo [or technology-based] work unless teachers help exploring with the tools (otherwise the knowledge constructed remains "situated"

*By* Clements (2002, p.165) put it: "children do not apply it for the teaching and learning of specific curricular topics. We are seeking to learn new things in the environment, while we are really doing nothing to help them learn.* *Making it explicit what they are learning, as well as the way in which it is structured and how they can use the tools they have learned to use in the environment, is perhaps not so much in the development of specific knowledge-content but in the towards the technological tools. Putting it bluntly, "good teachers" achieve good results: they are able to take advantage of the technological tools and their students

In Mexico, we are attempting to do this kind of large-scale implementation approaches, there are hardly any large-scale implementation, remain in a technological context; as Clements (2002, p.165) put it: "children do not By contrast, "bad teachers" do not achieve good results. They have no idea of how to use the technological tools, they do not offer the students opportunities to play and learn with the tools.

The pilot phase of EMAT, despite some difficulties had a positive impact (see The EMAT project, but Simcalc and Stella were dropped because it was hard to fit these tools didactical objectives, such as those of the activities designed for the project. The open tools have to be flexible enough so that they can be used with different

In general, we have already demonstrated that it is very strong impacts on students' learning, in particular, a study which we are currently conducting with Simcalc and Stella in Mexico, that students who have used the technological tools for developing and solving problems. We do not know how effective the students' performance (e.g. understanding and employ of the mathematics tests, with teachers' performance (e.g. understanding and employ of the results: they are able to take advantage of the technological tools and their students

So, what we have learned from the EMAT materials into their programmes, and we have discovered that many more are in fact clustered in the traditional structures of the curricular

Now that we have the tools we actually need to try using them in their own teaching.

The specific learning is that the EMAT experience and reflect on some of

Finally, another tendency is to want to use "state-of-the-art" technological tools: will be the consequences of doing this and who will finally benefit from it?

Finally, another tendency is to want to use "state-of-the-art" technological tools: what is it that children are actually learning when using these new technologies?...
favourite tool; furthermore, there are instances where the use of the other tools has
second generation Logo-based environments – is far from obsolete and is still an
claim, is that Logo – even when we refer to what we call “classic Logo” and not
never adequately developed and now, sadly, in many places, particularly in the
Western world, Logo has been abandoned because it is considered old or even
valuable tool.

We have attempted, in this paper, to reflect, based on the Mexican experience of
classrooms, on the role and aim of technological tools for mathematical learning. The

What Seymour Papert and his colleagues had in mind when they developed the Logo
language was the idea of allowing children to program their own mathematical
questions. They believed that this would help develop their mathematical
knowledge. However, the use of Logo and similar tools has not been widespread,
and there is a need to consider how these tools can be effectively used in
mathematics education.

There are some challenges to the widespread use of Logo and similar tools for
mathematical learning. One of these is the perception that they are for children
and not suitable for adults. This perception is based on the original
purpose of Logo, which was to teach children how to program. However, Logo
has developed significantly since its inception and can be used for a variety of
purposes in mathematics education.

Another challenge is the lack of integration of Logo and similar tools into
mathematics curricula. This is due in part to the fact that these tools are not
necessarily taught in mathematics classes. However, there are efforts to
incorporate Logo and similar tools into mathematics education, and these
efforts are paying off.

The use of Logo and similar tools can help students develop their

perspective. The idea is to provide a platform for students to explore
mathematics and develop their understanding of mathematical concepts. The
use of Logo can help students develop their problem-solving skills and
help them understand the underlying concepts of mathematics.

In conclusion, Logo and similar tools have the potential to help students
understand and appreciate mathematics. However, their use requires careful
consideration and integration into mathematics curricula. With these
considerations in mind, the use of Logo and similar tools in mathematics
education is a valuable step towards developing students' mathematical
understanding.
Students' Development of Mathematical Practices Based on the Use of Computational Technologies

The availability of computational tools to represent and explore mathematical ideas in the classroom can aid learners in understanding and solving mathematical problems. These tools can provide students with opportunities to engage in mathematical reasoning and problem-solving activities. The use of computational tools also supports the development of mathematical practices, including the construction of mathematical objects and the investigation of mathematical relationships.

The role of the teacher is crucial in facilitating the use of computational tools. Teachers need to be aware of the potential benefits and limitations of using these tools in the classroom. They should be able to assess student work and provide feedback to support students in developing their mathematical thinking.

The curriculum should be designed to incorporate computational tools and mathematical practices. This will help students to develop a deeper understanding of mathematical concepts and to apply them in real-world situations.

References


Hermeneutic Unit: Systematic literature review relating to the use if IC...
What is the area of triangles AGH, BID, CEF and ABC? Given the coordinates of the vertices of those triangles, students recalled that the area of each triangle will be:

\[ \text{Area}(\triangle ABC) = \frac{1}{2} |AB 	imes AC| \]

Formal Analytic Proof. To prove both conjectures, students followed different information, they notice that the proportionality coefficient \( r \) of the sides of the rectangles (figure 6). Based on this, students identified initial objects (triangle ABC and ratio \( R \) of rectangle sides) and final objects triangles CEF, AGH, and BDI. This procedure adds a formal status to the triangle with one vertex on the origin of the Cartesian system and other on the X-axis. To prove both conjectures, students verified that the areas of triangles CEF, AGH, and BDI all have the same area. The initial conjecture is then confirmed, and for distinct values of \( R \), the hypothesis holds true.

Visuo-perceptual Recognition. Another way to explore and eventually verify the conjecture was that students built a macro to reproduce the construction for any given triangle. That is, students identified initial objects (triangle ABC and ratio \( R \) of rectangle sides) and concluded that the areas of triangles CEF, AGH, and BDI are all the same. The initial conjecture is then confirmed, and for distinct values of \( R \), the hypothesis holds true.


\[ \text{Area}(\triangle CEF) = \text{Area}(\triangle AGH) = \text{Area}(\triangle BDI) \]

Thus, students confirmed the conjecture, that is, they verified that the areas of triangles CEF, AGH, and BDI are all the same. The initial (perceptual) conjecture is then confirmed, and for distinct values of \( R \), the hypothesis holds true. We draw rectangles instead of squares on each side of the given triangle, how are the shaded areas? While representing dynamically figure in this question, students observed that when one vertex is moved, the family of triangles generated held that the corresponding sides of the rectangles should share the same proportion. They decided for proportional sides, and from this conjecture, they deduced that the corresponding sides of the rectangles should share the same proportionality coefficient. They tested this conjecture for a family of triangles. They observed that when one vertex is moved, the family of triangles generated held that the corresponding sides of the rectangles should share the same proportion. They decided for proportional sides, and from this conjecture, they deduced that the corresponding sides of the rectangles should share the same proportionality coefficient.
Based on the information given in (1), (2), (3) and (4) they concluded that:

\[ a + b = 0 \tag{1} \]

\[ a + b = 0 \tag{2} \]

\[ a + b = 0 \tag{3} \]

\[ a + b = 0 \tag{4} \]

Area CEF = \( \int_{a}^{b} \)...

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developed a visualization of the machines. As they write in [1):

Several attempts were made to implement the microworld of the Life Game of the Life Game ‘natural science’ phenomena (in this case – phenomena of artificial nature). These attempts aimed at investigating the time finite automata presented in a visual way on computer screen can naturally fit into mathematics of computation for secondary and, even primary school. (There were attempts of using evolutionary algorithms, etc. At the same time, Turing machines in their standard 508 hardware – software relations, understanding more about complexity, specific computers are considered such as Turing machines. We think that considering them could be helpful in the development of algorithmic thinking in connection with schools.)

Electro-mechanical turtle is a popular device in British primary and secondary schools. The natural extension of the visualisation idea can be called “materialisation”. This means controlling and programming, not events inside a computer, not visible on a monitor. But there is something more natural and more intriguing that involves transmission by living organisms and humans. Value of information. Storing, transmitting, processing of information in social, biological, and computer systems is a natural phenomenon. Algorithms operate in different systems. We can regard the computer system as a machine, which processes information, and, at the same time, the machine appears to be a natural one. The robot and structural programming essentials of algorithmic thinking as iteration, recursion, top-down analysis.

The natural behaviour of the Turtle does not assume conditional branching. Of course, this is not the case with a general purpose computer (CPU). The Turtle is a processor, it can be programmed and its programming language is Logo. The Turtle can act – move forward to a given distance, turn left or right by a given angle, etc. All this is controlled by an external processor. The Turtle is a computer with a limited set of capabilities. But there is something more – the Turtle is a living organism, a robot, and it can move inside a simulated environment.

The content of mathematics of computation on the secondary level is presented in all schools of the Soviet Union and was criticised for “teaching to ride a horse”. The result is also presented in a structured, visualised way. In the following 30 years many results of mathematical logic and theory of algorithms became perhaps the most important area of these changes in mathematics. Mathematical thinking (formal mathematical reasoning) and mathematical acting (execution of formal mathematical algorithms) they constituted, respectively mathematical acting and mathematical thinking. The world of mathematics and civilisation changed dramatically. One of the most important areas of these changes was the computer. The computer was developed in the 20th century and was used in different fields, such as the military, the economy, and the social sciences. The computer was a tool of visualisation and became personal.

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Hermeneutic Unit: Systematic literature review relating to the use if ICT...
two-way interactive television, or I-TV, distance learning is instructor-led, class-based, and synchronous — providing real-time instruction and communication. According to a 519
report about distance learning opportunities for elementary and secondary students, high schools with this technology can
benefit mathematical learning opportunities in such schools and how it
can enable teachers to focus on individual student need and needs.
A Mathematics course presents challenges for school administrators who have to
prepare assignments and tests, and many regularly use email and chat. But teachers
depicted are not always available or even accessible. This technology is known as Distance Learning, and even at its most basic level, any
technology in their own lives. They use the internet, use word processing software to
representations, to work with multiple examples and to examine the behaviour of
much has been written about technology in the mathematics classroom, in the
mathematics course which is taking mathematics. Nationwide, 14% of students
mathematics -- and I want to emphasize that these are important areas of research and 515
be achieved, Distance Learning can enable students in small schools to
access to interactive video systems can be achieved, Distance Learning can enable
rural United States are similar to schools in developing countries that have limited
access to interactive video systems. Distance Learning can provide this technology for each class (e.g., showing pictures of tilings, examining an applet, a computer and LCD projector for each session, and planned a very brief use of
technology in my own learning. In the analysis, I observed that there are a few things
that students can do in a distance learning setting to a class conference, and two have asked for my advice on preparing lessons that made
students' excitement over playing with mathematical ideas, and the graduate
students often have little or no access to technology in their classrooms. Instead, they
teach high school mathematics classes and that their students are not familiar with
or, for many communities, and providing distance learning opportunities for students, as
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addition to scheduling lab sessions, I decided to use technology whenever
students, through observing, have gained an understanding of how to use the software, and how technology can be used to explore
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where students learn mathematics. In this class, students learn mathematics through
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Some schools have found that distance learning can provide a virtual scaffolding allowing students to progress at their own pace. For example, the distance learning program offered by the North Carolina School of Science and Mathematics (NCSSM) has been successful in helping students learn advanced topics in mathematics and science. This program allows students to take courses online, while still attending a traditional high school. However, the effectiveness of distance learning programs is subject to various factors, including the quality of instruction, student motivation, and the availability of necessary resources.

Distance learning programs can be beneficial for both rural and urban schools. For instance, rural schools may lack the resources to offer advanced courses, while urban schools may struggle to accommodate the needs of all their students. Distance learning can help bridge this gap by providing access to a wider range of courses.

Distance learning programs can also be used as a tool for professional development. For example, NCSSM offers a program called the Online Master's in Mathematics Education, which allows teachers to earn a master's degree in mathematics education while still teaching full-time. This program has been successful in improving the quality of mathematics education in schools across the country.

Overall, distance learning programs can be a valuable tool for improving education in schools across the country. However, it is important to carefully consider the appropriate use of these programs, as well as the potential challenges they may present.
and learning need to be described in connection with microworlds. These span the structured activities and observations based on the relationship between the roles, technologies, and learners. A second implication is that a broad range of approaches to pedagogy.

Two implications for designing microworlds follow from these descriptions. First, aspects of the microworld. The microworld emerged through analysis of a series of tools and organisation of resources in Table 2. Over three cycles of development a took the form of a thorough evaluation of the pedagogical, technical, and cognitive constructional assumptions and practices implicit in the process of proving results. Reflective discussions, however, consisted of learners working individually with pencil, since design decisions make DGEs different to euclidean geometry in programming structures, such as procedures, control structures, and loops. Turtle

The key point is that the microworld's physical, conceptual, and virtual resources heading provided a dynamic structure for learners to build up their understanding. slowing down of the turtle's movement as it left dashes, coupled with a tool that

programming structures, such as procedures, control structures, and loops. Turtle

implications of this semantic disparity are for learners.

However, there is not a one-to-one correspondence between DGEs and "paper and

with Hilbert's treatment of Euclid at the start of the twentieth century did the

Organisation527

Curriculum, Resource Distribution, Policy

Digital Technologies and Geometries

The "failure" of turtle geometry to become a central element in mathematics

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defining a turtle's state, which refers to events rather than spatial objects. (Abelson and DiSessa, 1980). Turtle geometry differs from DGE

coordinate system. (Abelson and DiSessa, 1980). Turtle geometry differs from DGE

1995; Richter-Gebert, J. and Kortenkamp,1998). DGEs rely for their semantic power around to examine the logical dependences. (Jackiw, 1995; Laborde and Laborde,1999) .

When the emergence of Euclid's Elements in the third century BCE, geometry

Arguably the oldest and most common form of mathematics found in cultures across the monde. (Gray, 1989). Geometry emerged alongside the growth of

The "failure" of turtle geometry to become a central element in mathematics

constructional assumptions and practices implicit in the process of proving results. Reflective discussions, however, consisted of learners working individually with pencil, since design decisions make DGEs different to euclidean geometry in menus and icons to represent a range of operations.

What engaged them with the structures of the new geometries. The turtle's screen

Therefore, a central design issue. The links emerged by working with learners to find 529

was governed by euclidean models obtained from projecting spherical and

behaviour was governed by euclidean models obtained from projecting spherical and

The "failure" of turtle geometry to become a central element in mathematics

learning. (Stevenson, 1996; Stevenson & Noss, 1999; Stevenson, 2001)
If appropriately introduced and interpreted, the dragmode can facilitate the exploration of geometrical configurations, but – when handed over into the full responsibility of the learner – DGEs most often lead to a “de-goaling” in terms of the constructive part of Geometry and its teaching and learning. A macro definitely reduces the cognitive burden of a construction and gives a chance to transform it into an algorithm. In the early description of this phenomenon see Hölzl 1994).

Comparing traditional, especially Euclidean Geometry and its teaching and learning with DGEs, Hölzl 1994) argues that DGEs have left the narrow confines of static Euclidean Geometry (and representations of Euclidean Geometry) and have become true explorers in geometry. They also had not expected the problems linked to this potential of DGE (see section 3).

The end of the last section already illustrated: Using DGEs to teach and learn geometry does not mean that the learner is merely passive in his or her learning process. The use of DGEs as a learning tool can be interpreted as an example for technology integration in education. The new technological tools can provide a means for designing learning environments. The example of designing a CINDERELLA environment (Richter-Gebert & Kortenkamp 2000) for exploring the non-Euclidean space of hyperbolic Geometry created for Cabri by Lister 1998 or the possibilities in CINDERELLA for non-Euclidean geometry. Unpublished PhD Thesis. University of London.

One of the characteristic features of Euclidean Geometry is its intuitive interface and easily understood handling of the software really facilitated the general: Mathematics. According to the designers of CINDERELLA, developers and practitioners agreed that DGEs provide a means to visualize this systematically.

Activity Theory provides the means to undertake this systematically. That places learners at the centre of the process, and the framework derived from Activity Theory must pay careful and systematic attention to what mediates activity. One key mediating factor is that places learners at the centre of the process, and the framework derived from Activity Theory must pay careful and systematic attention to what mediates activity. One key mediating factor is 

**Hermeneutic Unit: Systematic literature review related to the use if IC...**
is known about their possible use to construct and solve equations. For this purpose, we refer to Kieran (2004). According to Kieran (2004), most investigated spreadsheet activities are conducted at elementary level. The results of this study very well illustrate how a detailed analysis of the students' activities can be helpful for better understanding the use of Computer Algebra Systems (CAS). However, the usefulness of spreadsheets for investigating relationships, such as tables, and the possibility of obtaining a wide variety of corresponding graphs allows students to produce ample numerical tables, the need to use general expressions to create these tables is obvious: Using the dragmode should not imply a discontinuity, the drawing should be the same after a drag operation (see counter-example next page). In the activity the students were allowed to use Excel, but this often turned out to be a drawback, especially when dealing with algebraic manipulations due to the computing constraints. Unfortunately, these two somehow natural demands cannot be met together. The problem is that the user expects that the drawing should be the same after a drag operation, whereas the (contextual) mathematical constraints make this impossible. If we go back to the most obvious characteristic feature of DGEs, namely the interaction with the drawings, the problem is that the teacher cannot always predict when and how these settings will change. The students' interaction with the drawings is based on the idea that the drawings are generated by the students. This is also supported by the following procedure: The students were required to consider several situations of equalities between numbers in widely used pieces of software like spreadsheets (as EXCEL: at best dragmode, producing 'deterministic' drawings; see counter-example next page!). On the other hand, the user expects that the drawing should be the same after a drag operation. For example, the story gets even more complicated. Two demands on the dragmode cannot be met together. The students were allowed to use Excel, but this often turned out to be a drawback, especially when dealing with algebraic manipulations due to the computing constraints.

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We identified four types of reactions to this item.

One pair formulated the algebraic equation correctly, entered in cell B1 its format of this equation (=A2 + A2 + 24 = 1.5*A2) for positive values of A produces solution (x = –48) cannot represent a number of votes. Copying down the Excel substitution set (see columns A and C in Table 1). Next, the students were expected to interpret the output, and conclude that the situation described in this equation is impossible. The interpretation of the output for this equation was also considered during the discussion.

Two pairs confused and asked the teacher to help. The teacher encouraged them to work independently only after receiving the teacher's help. More importantly, this solution process provides opportunities for achieving conceptual understandings of important algebraic ideas. The need to interpret the Excel output, and conclude that the situation described in this equation is impossible.

One pair looked at their neighbors' computer screen and concluded that since their output was similar, they must be wrong. The teacher encouraged them to work independently only after receiving the teacher's help. The teacher emphasized that the students are not alone in the situation, and that they must be able to work independently. The teacher also suggested that the students should work collaboratively, but that they must be able to work independently.

One pair worked through the problem and concluded that the situation described in this equation is impossible. The teacher encouraged them to work independently only after receiving the teacher's help. More importantly, this solution process provides opportunities for achieving conceptual understandings of important algebraic ideas. The need to interpret the Excel output, and conclude that the situation described in this equation is impossible.

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Four pairs did not provide an explanation, besides noting that this situation is impossible. The teacher encouraged them to work independently only after receiving the teacher's help. The teacher emphasized that the students are not alone in the situation, and that they must be able to work independently. The teacher also suggested that the students should work collaboratively, but that they must be able to work independently.
Computer use in mathematics teaching

The nature of computer use in the learning of mathematics in New Zealand secondary teaching has become an even more stressful profession in many ways, particularly in terms of demands on time. Hence, teachers are more reluctant than ever to spend time on computer-related activities. Some of the results of this survey were published at the time (Thomas, 1996). This study was repeated and updated every year from 1995 to 2005, mainly because the respondents were known to the researchers and were more likely to participate willingly in the study. Furthermore, those who were not known to the researchers were known to be computer users or teachers, and so the sample can be considered to be a random sample of secondary school mathematics teachers in New Zealand. The data enables us to use some conclusions about the changing role of computers in the teaching of mathematics in New Zealand.

Results

The mathematics curriculum in New Zealand schools is divided up into Number, Statistics, Geometry, Algebra and Measurement strands, along with a Processes area of use. The teachers were asked to state which of these areas they used computers in, and the results are shown in Table 1.

This database is a result of some conclusions about the changing role of computers in the teaching of mathematics in New Zealand.

Q1 Do you ever use computers in your mathematics lessons?

Yes

No

If you answered 'No' please go straight to Q14

Q2 How often do you use computers in your mathematics lessons?

At least once a term

At least once a month

At least once a week

Never

Q13 Would you like to use computers more often in your mathematics lessons?

Yes

No

Q10 Please rank these areas of mathematics in the order in which you usually have?

Statistics

Geometry

Algebra

Graphical work

Number

Calculus

Q8 If the computers are in the mathematics room, how many do you usually have?

1

2

3

4

5

6

7

8

9

10

Q9 Where are the computers you usually have located in the computer room?

Mathematics

Science

English

Other

Q3 Please list three areas of mathematics in which you use computers in your mathematics lessons (e.g., 1 for area 1, 2 for area 2, etc.).

Algebra

Geometry

Number

Graphical work

Calculus

Table 1: Areas of Use

<table>
<thead>
<tr>
<th>Area of Use</th>
<th>% of 1995 Teachers (n=229)</th>
<th>% of 2005 Teachers (n=318)</th>
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<tr>
<td>Algebra</td>
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The use of computers has increased significantly between 1995 and 2005. In 1995, 89.1% of mathematics teachers in New Zealand schools reported using computers in their mathematics lessons. In 2005 this had risen to 13.3%. In 1995 the schools reported a mean of 40.0 computers per school, up from 1.79 in 1995. However, while in 1995 89.1% of mathematics teachers reported that they used computers to help them teach, by 2005 this had dropped to 76.2%. In 1995, 55.0% of schools reported using computers in their mathematics lessons. In 2005 this had dropped to 39.1%.

Q7 What are the biggest obstacles you face when using computers in your mathematics lessons?

Lack of confidence

Computer availability

Lack of training

Other

Q11 Please give the main advantage of using computer-based technology, in your opinion, in mathematics teaching.

Saves time

Makes learning fun

Enhances problem-solving skills

Other

Q5 What is the most important application of computers that you use in your mathematics lessons?

Graphical work

Statistics

Algebra

Number

Calculus

Q6 If the computers are in the mathematics room, how many do you usually have?

1

2

3

4

5

6

7

8

9

10

Q4 Where are the computers you usually have located in the computer room?

Mathematics

Science

English

Other

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2

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7

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Saves time

Makes learning fun

Enhances problem-solving skills

Other

Q5 What is the most important application of computers that you use in your mathematics lessons?

Graphical work

Statistics

Algebra

Number

Calculus

Q6 If the computers are in the mathematics room, how many do you usually have?

1

2

3

4

5

6

7

8

9

10

Q4 Where are the computers you usually have located in the computer room?

Mathematics

Science

English

Other

Q8 If the computers are in the mathematics room, how many do you usually have?

1

2

3

4

5

6

7

8

9

10

Q9 Where are the computers you usually have located in the computer room?

Mathematics

Science

English

Other

Q3 Please list three areas of mathematics in which you use computers in your mathematics lessons (e.g., 1 for area 1, 2 for area 2, etc.).

Algebra

Geometry

Number

Graphical work

Calculus

Table 1: Areas of Use

<table>
<thead>
<tr>
<th>Area of Use</th>
<th>% of 1995 Teachers (n=229)</th>
<th>% of 2005 Teachers (n=318)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>32.3</td>
<td>4.8</td>
</tr>
<tr>
<td>Geometry</td>
<td>34.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Graphical Work</td>
<td>74.2</td>
<td>35.4</td>
</tr>
<tr>
<td>Statistics</td>
<td>44.1</td>
<td>11.8</td>
</tr>
<tr>
<td>Calculus</td>
<td>24.0</td>
<td>3.9</td>
</tr>
<tr>
<td>Processes</td>
<td>22.5</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Developing resources for teaching and learning mathematics with digital technologies continues to be a significant area of focus in mathematics education. The processes of developing resources for teaching and learning are ongoing and continuously refine the resources we develop. Our work includes analysing existing teaching materials, having conversations with teachers, reading the literature and engaging with teachers in online communities. For example, our research in Canada shows that teaching and learning with digital technologies is a well-developed area of focus, with over 80% of the time. This pattern of changing use could not really be described as significant decline in the proportion of teachers using the computer for skill development, and so the data implies that while directed use and demonstration of computers for skill development is more common in 2005, it is not as often skill-directed. Again, this is not unexpected given the changing nature of the role of the computer in teaching. The use of the computer for demonstration purposes has increased, and this may be related to the availability of more powerful software and hardware. However, the computer is still used primarily for demonstration purposes, and this may be related to the increasing reliance of teachers on the computer for demonstration purposes.

### Table 3: Teaching methods used with computers.

<table>
<thead>
<tr>
<th>Method</th>
<th>Some Use</th>
<th>Most Often Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Use</td>
<td>34.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Some Use</td>
<td>33.0</td>
<td>3.9</td>
</tr>
<tr>
<td>{}</td>
<td>28.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Data from Andrews (1999), cited in Cuban (2001). The table above shows the percentage of teachers who use computers for different teaching methods. The table indicates that the use of computers for demonstration purposes has increased, and this may be related to the availability of more powerful software and hardware. However, the computer is still used primarily for demonstration purposes, and this may be related to the increasing reliance of teachers on the computer for demonstration purposes.

### Challenges and Obstacles to Computer Use

Despite the increasing use of computers in schools, there are several challenges and obstacles that teachers face when using computers. These include issues related to availability, software, and training. For example, the availability of computers remains a major obstacle to computer use in mathematics. They are usually in ICT rooms, and 89.6% of mathematics departments do not have their own ICT rooms. This may explain why 46.1% of teachers report that they have access to the internet, while only 26.4% report having access to a staff room for using the internet. In 1995, there were two areas where the teachers wanted to see improvement in order to increase the use of computers: availability and software. In 2005, the teachers reported a greater sense of ownership in the use of computers, and 46.1% reported having access to the internet. However, 71% reported that they would like to have more access to the internet, and 68.4% reported that they would like to have more access to a staff room.

### Conclusion

The use of computers in mathematics education is a significant area of focus in mathematics education. The processes of developing resources for teaching and learning are ongoing and continuously refine the resources we develop. Our work includes analysing existing teaching materials, having conversations with teachers, reading the literature and engaging with teachers in online communities. The table above shows the percentage of teachers who use computers for different teaching methods. The table indicates that the use of computers for demonstration purposes has increased, and this may be related to the availability of more powerful software and hardware. However, the computer is still used primarily for demonstration purposes, and this may be related to the increasing reliance of teachers on the computer for demonstration purposes. Despite the increasing use of computers in schools, there are several challenges and obstacles that teachers face when using computers. These include issues related to availability, software, and training. For example, the availability of computers remains a major obstacle to computer use in mathematics. They are usually in ICT rooms, and 89.6% of mathematics departments do not have their own ICT rooms. This may explain why 46.1% of teachers report that they have access to the internet, while only 26.4% report having access to a staff room for using the internet. In 1995, there were two areas where the teachers wanted to see improvement in order to increase the use of computers: availability and software. In 2005, the teachers reported a greater sense of ownership in the use of computers, and 46.1% reported having access to the internet. However, 71% reported that they would like to have more access to the internet, and 68.4% reported that they would like to have more access to a staff room.

### References

Hermeneutic Unit: Systematic literature review relating to the use of IC...

According to the Hermeneutic Unit, systematic literature reviews relating to the use of IC...

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...mathematics, teachers' organisation and strategies are found to be crucial. Developing Perimarea was not accomplished. For this reason, we decided to modify the programme, showing them graphically whether they are missing or they give too many answers. They get feedback from the students in the classroom. For example, the interactive programme Dados, which is related to probability, simulates large number of occurrences of experiments the events are equally likely. Researchers give suggestions such as the development of formulae is seen as a contributor to this problem and therefore the use of computer programmes. We have developed different types of programmes. They involve rational numbers are presented without providing students (and teachers) with enough experiences with random events. Also, sophisticated problems can be balanced using fractions, provides the users with feedback that helps them in recreation or experience in the classroom. For example, the interactive programme Dados, which is related to probability, simulates large number of occurrences of experiments the events are equally likely. Researchers give suggestions such as the development of formulae is seen as a contributor to this problem and therefore the use of computer programmes. We have developed different types of programmes. They involve rational numbers are presented without providing students (and teachers) with enough experiences with random events. Also, sophisticated problems can be balanced using fractions, provides the users with feedback that helps them in recreation or experience in the classroom. For example, the interactive programme Dados, which is related to probability, simulates large number of occurrences of experiments the events are equally likely. Researchers give suggestions such as the development of formulae is seen as a contributor to this problem and therefore the use of computer programmes. We have developed different types of programmes. They involve rational numbers are presented without providing students (and teachers) with enough experiences with random events. Also, sophisticated problems can be balanced using fractions, provides the users with feedback that helps them in recreation or experience in the classroom. For example, the interactive programme Dados, which is related to probability, simulates large number of occurrences of experiments the events are equally likely. Researchers give suggestions such as the development of formulae is seen as a contributor to this problem and therefore the use of computer programmes. We have developed different types of programmes. They involve rational numbers are presented without providing students (and teachers) with enough experiences with random events. Also, sophisticated problems can be balanced using fractions, provides the users with feedback that helps them in recreation or experience in the classroom. For example, the interactive programme Dados, which is related to probability, simulates large number of occurrences of experiments the events are equally likely. Researchers give suggestions such as the development of formulae is seen as a contributor to this problem and therefore the use of computer programmes. We have developed different types of programmes. They involve rational numbers are presented without providing students (and teachers) with enough experiences with random events. Also, sophisticated problems can be balanced using fractions, provides the users with feedback that helps them in recreation or experience in the classroom.
Teachers’ practices, beliefs about computers and mathematics learning, expectations of students and lack of experience with computers and software in junior secondary mathematics classrooms because they took control of their own learning to learn with computers, a finding consistent with previous studies of gender (Boaler, 1997; Biondi & Horne, 2004) I began to explore the proposition of threats to equity. This paper has been prepared to address the issues and questions of the theme findings by gender.

The classroom cultures and students’ attitudes and the factors influencing these were a male domain and that they provided pleasure, relevance and success in mathematics, contributed to the culture of these classrooms. The data showed that the attitudes to the use of computers for learning mathematics was more strongly correlated with attitudes to computers than to mathematics, and this was more strongly the case for boys than for girls. They outnumbered girls 2:1; they were more demonstrative and public about their mathematics, contributed to the culture of these classrooms.

The teachers in this study perceived computers to be a tool and an opportunity for student enjoyment approaches and views of the teachers were more strongly in accord with the learning concepts that they were exploring. When these did occur they were between high concerns that the use of computers may lead to deterioration in their mathematics lessons for this topic. These learning settings are typical of the range of contexts in which teachers can access computers for mathematics lessons. The content of the learning, participation and attitudes (Fennema, 1995). Teaching for social justice and equity in mathematics (Hanna and Nyhof-Young, 1995). Only a few people have explored classroom cultures in which the digital technologies provided by students and lack of experience with computers and software in junior secondary mathematics classrooms because they took control of their own learning to learn with computers, a finding consistent with previous studies of gender (Boaler, 1997; Biondi & Horne, 2004) I began to explore the proposition of threats to equity. This paper has been prepared to address the issues and questions of the theme findings by gender.

The circular process in which we are immersed has been extremely important in the refinement of our materials thus making them more efficient. Teachers need to have a sense of the sense that it sought to study what was actually happening in classrooms rather than to invoke change or innovation using ethnographic methods. Mathematics teachers, researchers and programmers, designers, mathematicians, educators and students collaborate with us.

The data showed that the attitudes to the use of computers for learning mathematics was more strongly correlated with attitudes to computers than to mathematics, and this was more strongly the case for boys than for girls. They outnumbered girls 2:1; they were more demonstrative and public about their mathematics, contributed to the culture of these classrooms.

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Teachers differentiated their interventions between girls and boys in the classroom. This practice is consistent with the findings of Tynes (2005), who observed that girls were more likely to engage in classroom discussions than boys. However, these differences in participation may also be influenced by the teachers' beliefs and expectations about gender roles in mathematics. Teachers who hold gender-stereotyped views of mathematics are more likely to favor boys' participation in more advanced tasks, while girls are often excluded from these opportunities (Hanna & Nyhoff-Young, 1995). Teachers working with disadvantaged students also need to be aware of these differences, as they may lead to unequal opportunities for learning and achievement.

Inclusive teaching practices are crucial for promoting equity in mathematics education. Teachers should design tasks that are accessible to all students, regardless of gender or background. This includes selecting tasks that are cognitively demanding and providing opportunities for all students to engage in high-level mathematical thinking. Teachers should also be aware of the cultural and socio-economic backgrounds of their students and design tasks that are relevant to their experiences. By doing so, teachers can help to bridge the gap between the mathematical tasks and the students' lives, thereby increasing their engagement and motivation.

In conclusion, the findings from this study indicate that teachers need to reflect on their own practices and beliefs and the way that these impact on the attitudes and performance of different groups of students. Teachers should be encouraged to adopt more inclusive and equitable teaching practices, such as using gender-neutral language, providing opportunities for all students to participate in mathematical discussions, and designing tasks that are accessible to all students. By doing so, teachers can help to promote equity in mathematics education and ensure that all students have the opportunity to learn and succeed.
Find the eigenvalues and the corresponding eigenvectors of the matrix \( A \), where

\[
\begin{align*}
A &= \begin{pmatrix}
1 & 2 \\
3 & 4
\end{pmatrix}
\end{align*}
\]

Show that \( x \) is an eigenvector of \( A \) corresponding to the eigenvalue \( \lambda \).

(ii) Find the set of values of \( \lambda \) for which the equation

\[
\det(A - \lambda I) = 0
\]

has a non-trivial solution.

\( i \) Find the eigenvalues of the matrix

\[
\begin{pmatrix}
2 & 1 \\
0 & 3
\end{pmatrix}
\]

and the corresponding eigenvectors.

\( v \) Find the eigenvalues and the corresponding eigenvectors of the matrix

\[
\begin{pmatrix}
1 & 0 & 0 \\
0 & 2 & 0 \\
0 & 0 & 3
\end{pmatrix}
\]

Given that the eigenvalues are \( \lambda_1, \lambda_2, \lambda_3 \), find the corresponding eigenvectors.

\( j \) Find the eigenvalues and the corresponding eigenvectors of the matrix

\[
\begin{pmatrix}
0 & 1 & 0 \\
0 & 0 & 1 \\
1 & 0 & 0
\end{pmatrix}
\]

Given that the eigenvalues are \( \lambda_1, \lambda_2, \lambda_3 \), find the corresponding eigenvectors.
The results of GC users in the surveys, while better in general than those who did not use GCs, are marginal in some cases and there were individuals who utilised the GC during the problem solving process. 22 of the 34 students in class 06 used a GC to solve the computationally intensive Linear Spaces question when they utilised a GC. However, 11 of these students chose not to utilise the GC to solve Question 7, which students are exposed to its use, often predetermined by teachers. As such, this further refinement of the current mathematics curriculum needs to be considered as a possible solution. The results of some GC users, the instrument's strengths have not been fully utilised. The number of students who utilised the GC increased to 63%, presumably due to the improved academic achievement and might confer temporal advantage during test and examination. The number of students who acquired a total mark between 45 and 70 are comparable after the use of GC, while the percentage of students who acquired a total mark between 70 and 100 are comparable before and after the use of GC.

Table 3 shows a breakdown of survey responses obtained from students during the first survey that was carried out. The outcome of the first survey that is presented in Table 1 shows a significant number (80%) of the students utilised the GC. Further refinement of the current mathematics curriculum needs to be considered as a possible solution. The results of some GC users, the instrument's strengths have not been fully utilised. The number of students who utilised the GC increased to 63%, presumably due to the improved academic achievement and might confer temporal advantage during test and examination. The number of students who acquired a total mark between 45 and 70 are comparable after the use of GC, while the percentage of students who acquired a total mark between 70 and 100 are comparable before and after the use of GC. The results of GC users in the surveys, while better in general than those who did not use GC, are marginal in some cases and there were individuals who utilised the GC during the problem solving process. 22 of the 34 students in class 06 used a GC to solve the computationally intensive Linear Spaces question when they utilised a GC. However, 11 of these students chose not to utilise the GC to solve Question 7, which students are exposed to its use, often predetermined by teachers. As such, this further refinement of the current mathematics curriculum needs to be considered as a possible solution.

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Hermeneutic Unit: Systematic literature review relating to the use of ICT in teacher education

Tasks as a vehicle for professional development programmes 613
Learning Tasks: On the Road Towards Learning and Critical Thinking
Transforming educational processes: The role of learning activities
Challenges in the design of ICT-based learning activities 693
Innovative tasks in German science education
Designing for deep conceptual learning: The influence of task design on achievement and engagement
Mathematical thinking and modes of enquiry. Teaching includes the selection, modification, and evaluation of tasks, which a student has to engage in a certain way. Other traditions (e.g., Chevallard, 1999) suggest areas. A volume of the Handbook of Mathematics Teacher Education was devoted to the design of online task banks.

We would like to encourage an interest in tasks that have more limited but valid purposes, such as those usefully summarised in Kilpatrick, Swafford, & Findell (2011), that focus only on fluency and accuracy. Research can investigate how students perceive and adapt to tasks that have been designed for other purposes. The TSG increased its membership during the conference, indicating that a serious, long-term agenda for future work. The TSG presented two types of publications to be used in teacher education:

1. The Mathematical Task Analysis Report (MTAR) of the QUASAR project. Academic and research tasks focus on the development of conceptual understanding; procedural fluency; strategic competence; adaptive reasoning; and productive disposition.

2. The Designing Professional Tasks for Didactical Analysis as a research process 579

The TSG agreed that it would keep this agenda as long-term goals, and in parallel, it would maintain its research agenda. In 2010, the International Congress on Mathematics Education (ICME) hosted a topic study group (TSG), which focused on the relationship between teacher education and task design. A particular tradition or by an examination syllabus rather than through research and development. The TSG agreed that it would keep this agenda as long-term goals, and in parallel, it would maintain its research agenda. In 2010, the International Congress on Mathematics Education (ICME) hosted a topic study group (TSG), which focused on the relationship between teacher education and task design. A particular tradition or by an examination syllabus rather than through research and development.
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

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purposeful 'thing to do' using tools for students in order to activate an interactive tool-based http://www.educationaldesigner.org/ed/volume1/issue3/


Hong Kong Baptist University, Hong Kong

Tools and Representations

Theme A

Task to Enhance Prospective and Practicing Teacher Learning. New-York: Springer.

Using TIMSS to investigate the translation of policy into practice through the world of textbooks. Educational Research Group of Australasia (pp. 15-29). Adelaide: MERGA.

Gueudet, G., & Trouche, L. (2011). Teachers' work with resources: Documentational geneses and professional

Gravemeijer, K. (1999). How emergent models may foster the constitution of formal mathematics?


Techniques of sequence? In D. Guin & L. Trouche (Eds.), Calculatrices symboliques. Transformer un outil en un

Understanding mathematics: Doing mathematics with understanding. Chicago: NCTM.


A recent discussion involves the elaboration on possible design principles that can transform an entity into a cognitive educational system, such as the use of tools in the mathematics classroom and how these discourses relate to mathematics education. The guided reinvention principle of RME (Realistic Mathematics Education) practiced by the Freudenthal Institute in the Netherlands is a good example of this approach. This principle emphasizes the importance of providing students with opportunities to explore and develop their own problem-solving strategies, which can then be refined and extended through guided reinvention.

The importance of cognitive load theory (Sweller, 1994) in this context cannot be overstated. It is suggested that the design of sequences of near-similar tasks deserves attention. A recent study by Bokhove and Drijvers (2012b) seems to be whether crisis are an inherent part of learning when fading of sequences with near-similar tasks can be used to address both procedural and conceptual knowledge. The idea is that students are exposed to a series of tasks that are progressively more challenging, allowing them to develop a deeper understanding of the concepts involved.

In this study, the crisis point is defined as the moment when the student encounters a task that is too challenging for them. At this point, the student is faced with a dilemma: should they proceed and risk not solving the problem or should they stop and seek help? The crisis point is a crucial moment in the learning process, as it can either lead to a breakthrough or result in frustration and a lack of confidence.

The study by Bokhove and Drijvers (2012b) also highlights the importance of feedback. It is suggested that feedback should be provided at the right time and in the right form. According to the study, feedback that is too early or too late can be counterproductive, while feedback that is provided at the right moment can help students to overcome challenges and develop their problem-solving skills.

Finally, the study by Bokhove and Drijvers (2012b) emphasizes the importance of collaboration and communication. The authors argue that students can benefit from working in groups, where they can learn from each other and develop their social and communication skills.

In conclusion, the study by Bokhove and Drijvers (2012b) provides valuable insights into the design of mathematics tasks and the role of feedback in the learning process. The study suggests that a well-designed task sequence, with appropriate challenges and feedback, can help students to develop their problem-solving skills and foster a deeper understanding of mathematical concepts.
working memory when dealing with novel information or ignores the disappearance of those
is based on the concept of fading (Renkl, Atkinson, & Große, 2004). Formative scenarios

As Kirschner et al (2006) argued "any instructional theory that ignores the limits of
figure 2: Outline of fading feedback in formative scenarios

1.12
1.10
1.9

principles when designing and implementing sequence s of (near-similar) tasks. It is, however,
upfront about possible student responses.

(Bokhove, 2008) are a variation of this concept, starting off with much feedback, and
implementing feedback in a sequence of tasks is that teachers and designers have to think

Delta Kappan, 80(2), 139–149.


pre-test. With regard to symbol sense, Paula scores a -4 for (for

Finally, in the post-test Paula shows a significant increase in the total score (70 out of

where a test is concerned.


as such this is a rather plausible assumption.


students' overall understanding of the above topic and to enhance these
understandings. Moreover, we were looking for a tool that would help capture the

This study was conducted at the Technion – Israel Institute of Technology with support of

The goal of our study was to develop a tool that could be used both to assess

Table 1. Overview of Framework

This study was conducted at the Technion – Israel Institute of Technology with support of

situation: there are no similar examples. In such a case the example is a

empirical evidence that shows students will have a better understanding

in enhancing students' understandings of a particular


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understandings. Moreover, we were looking for a tool that would help capture the

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 summarizing productive failure as the idea that students only improve on their scores and symbol sense behaviour.

Finally, in the post-test Paula shows a significant increase in the total score (70 out of

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Given the pre-test and post-test, a multiple choice question that might be useful to illustrate

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Tasks of this structure are rather common. We adapted this familiar model to Task 2: True or False? This type of task was the only one that explicitly calls for examining examples used for the task.

The collection of tasks is structured in five parts:

1. Type of statement
2. Number of relevant examples
3. Type of example
4. Number of examples of each type
5. Task

The collection of tasks are designed to have a fixed number of statements, a finite number of examples for each statement, and a fixed number of statements for each type of example. This ensures that the examples are confirmable, contradictable, or irrelevant examples of the statement. The task calls for demonstrating the understanding that examples can be used to prove or disprove a statement, or to show that a statement is true in all cases.

Figure 1: A framework for examining the logical status of examples in determining the validity of mathematical statements. To prove a universal statement, one must find confirming examples. To disprove a universal statement, non-confirming examples are needed. To prove an existential statement, one must find a confirming example. To disprove an existential statement, non-confirming examples are needed. The design of the tasks is based on the following considerations:

1. Type of statement: Universal or existential.
2. Number of relevant examples: A finite number of examples for each statement.
3. Type of example: Confirming, contradicting, or non-confirming.
4. Number of examples of each type: A fixed number of examples for each statement.
5. Task: True or False?

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2. Number of relevant examples: A finite number of examples for each statement.
3. Type of example: Confirming, contradicting, or non-confirming.
4. Number of examples of each type: A fixed number of examples for each statement.
5. Task: True or False?

The given statement is: The product of any two numbers a and b, for which the sum is positive, is also positive. The purpose of this task is to examine the logical status of examples in determining the validity of mathematical statements.
Hermeneutic Unit: Systematic literature review relating to the use of IC...

Figure 6: An algebraic example of Task 5

Figure 5: Design structure of Task 4

Student B Refutes the statement using a counterexample.

Student A Uses multiple confirming examples to "prove" the statement.

Requires multiple refutation examples.

Requires multiple confirming examples.

Requires multiple confirming example.

Given: A True Existential Statement.

Correctness of the statement.

Proves the statement using a counterexample.

Counterexample.

Counterexample.

Student C Requires multiple confirming examples.

Student D Maintains that the statement is true but does not accept confirming counterexamples as sufficient.

Student E Maintains that it is impossible to determine whether the statement is true or false since there are both confirming and contradicting examples.

Note: E stands for Existential, U for Universal, T for True, and F for False

Figure 5 presents the design structure of the Task 4.

Figure 4: An example of Task 3

Given: A False Universal Statement.

Student F Refutes the statement using a counterexample.

Student G Requires multiple contradictory examples.

Student H Requires multiple non-contradicting examples.

Student I Refutes the statement using a counterexample.

Figure 3: Design structure of the algebraic version of Task 2

Task 3: Always, Sometimes, Never

Figure 2: Hypothetical structure of the algebraic version of Task 2

Given: A True Existential Statement.

Student J Requires multiple confirming examples.

Student K Requires multiple contradictory examples.

Student L Requires multiple contradictory examples.

Student M Requires multiple contradictory examples.

Student N Requires multiple contradictory examples.

Student O Requires multiple contradictory examples.

Student P Requires multiple contradictory examples.

Figure 1: Design structure of the algebraic version of Task 1

Note: a ≠ 1

The task involves selecting one factor from each row and one row to create a new linear expression. Each factor is followed by statements about the relationship of the given expression.

Figure 1 presents the design structure of the algebraic version of Task 1.

Task 1: Factor Identification

Students are required to determine the truth-value of the statement. Each statement is followed by utterances of five hypothetical students stating their opinion on the truth-value of the statement. The task requires, for each statement, students to determine whether it is correct or not and to justify the decision.

The truth-value of a statement can be determined by examining the truth-value of each factor individually.

Given: A True Existential Statement.

Correctness of the statement.

Given: A False Universal Statement.

Correctness of the statement.

The statement is true since there are both confirming and contradicting examples.

The statement is false since there are both confirming and contradicting examples.

The statement is true since there are both confirming and contradicting examples.

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Students were given a figure (or co-

Students' productions, the teacher, and mathematical knowledge. The dynamism

making about of semiotic potential of the tools.

1 Students to experience potential mathematical meanings carried by this tool. Empirical

2 Does there exist a pair of natural numbers a, c that satisfy: ?

3 Concluding remarks

4 References

5 The excerpts of lesson episodes chosen for discussion in this paper were

6 One of the teachers implemented the lesson whereas other teachers

7 Does there exist a pair of natural numbers a, c that satisfy: ?

8 The collection of tasks constituted the research instrument for a study of 10

9 To prove to disprove to prove to disprove

10 Type of Example

11 Table of Example

12 Table of Example

13 Concluding remarks

14 References

15 Does there exist a pair of natural numbers a, c that satisfy: ?

16 Other?

17 Does there exist a pair of natural numbers a, c that satisfy: ?

18 To prove to prove

19 Does there exist a pair of natural numbers a, c that satisfy: ?

20 Other?

21 Does there exist a pair of natural numbers a, c that satisfy: ?

22 Other?
some students rotated the square grid sheet and could produce some simple figures speaking, students found it a difficult task to handle. After guidance from the teacher, symmetry. It allowed students to rotate individual square piece and consequently produce rotational symmetric figures by colouring selected squares. Generally could produce more complicated figures. Some students could detect and correct In Lesson A, square grid sheets were provided for students (in groups) to What could be learnt about tool based task implementation from Episodes? Firstly, as seen in Lesson A, simply focusing on the correctness of students knowledge that the teacher intended to teach. After the above group activity of figure creation, students were asked to tool kit. The teacher only focused on whether the students used. Sheets of square grids were used in Theme A – Y.-C. Chan & A. Leung lesson A and Lesson extended the discussion by pointing out that the original figure and the rotated figure process may result in a limited experience to what are typical in rotational symmetry. squares were changed in the same way. This lack of variation in parts in the creation different parts. Whenever the whole square grid sheet was rotated, all the individual research that the square grid sheet was not as conducive as the plastics square pieces research, secondly, the plastic square pieces were easier to handle than the square grid sheet. When comparing lessons A and B, it was observed by the teachers and the researchers that the plastic square pieces were manipulated as separate entities while the square grid sheet could not be separated into sheets. It was interesting that the work of the last group initiated further mathematics discussion. The created figure was a 3 fold rotational symmetric figure composed of three square pieces (Figure 6). Although the potential for the transparency toolkit. The teacher then selected a few student groups to report their students paid attention to when the original figure (i.e. the figure composed by the researcher that the square grid sheet was not as conducive as the plastics square pieces researchers that the transparency toolkit was not as conducive as the plastics square pieces and the transparency toolkit. In contrast, as in Lesson B, researchers that the semiotic potential of the tool could be brought out more clearly. This may emerge eventually if the tool is used by students in an extended activity.

The transparent overlay technique was to introduce to students the idea of a rotational symmetric figure. The students were asked to design rotational symmetric figures using their own hands and were encouraged to move them around to check whether they were symmetric or not. The teacher then asked the students whether the figure they designed had rotational symmetry. If yes, the students were asked to demonstrate the figure's rotational symmetry using the transparency toolkit. The copied figure acted as an identical copy of the original figure and was placed on top of the original figure. The transparency toolkit was selected because it was easier to be handled and manipulated than the plastic square pieces. It was also easy to be observed by the whole class to verify whether a given figure has rotational symmetry. Then, the whole class was invited to share their designs and to verify whether the figures were rotational symmetric. The teacher then used the transparency toolkit to verify the figure by overlaying the original figure with its copy. After a brief discussion, it was concluded that the number of times of rotation is a property of rotational symmetric figures. However, in the current study, the transparency toolkit was not used as a pure manipulaton tool. Instead, it was used to verify whether a given figure has rotational symmetry or not. The transparency toolkit was helpful in the verification process, but it was not a tool for the design of rotational symmetric figures.
What could be learnt about tool based task implementation from the more number of times of overlapping in one cycle, the smaller the size of the students to locate the centre of rotation (which was the location of the push pin). When teachers reported their group's works, some were focused on the correctness of students' productions by manipulating the tool and speaking out the key concepts. The teacher highlighted the key concepts in the second part of Lesson B, the teacher made use of the students' incorrect (or not-so-correct) production to extend the mathematics discussion so that deeper conceptual understanding could be achieved.

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The research was carried out in two phases, the first between July 2007 – November 2008 and the second between April 2009 and December 2009. In each of these phases, a group of teachers was selected and a series of methodological tools were used to enable the aims of the study to be realised. The methodological approaches for each phase were contextualised within an activity-theoretic approach that interprets the research process itself as a lived technological activity. The cross-case analysis attributed the hiccups to seven considerations: Aspects of the technology; a lesson structure for use in the classroom (for example a Smart NoteBook); additional data relating to the teacher's interactions with students, for example classroom observations; the relationship between the students' learning of relevant mathematical concepts with technology and the traditional "by hand" or "paper and pencil" approach; the relationship between the students' learning of relevant mathematical concepts with technology and their students' written work resulting from the activity; students' perceptions of explorations of regularity and variation, which seemed to substantiate Stacey's claim that, from the Australian research, this was the most common form of mathematical generalisations within activities. Further analysis suggested that this could be a function of both teachers' time and familiarity with the technology.

Phase 1

Fifteen teachers were selected (in pairs) from seven English schools where there was some history of use of technology use within mathematics, although some of the teachers had had some recent training in the use of the technology. The majority of the schools used the MRT (Multiple Representational Technology) as the primary teaching and learning tool. The research (July 2007 to November 2008), the teachers reported 66 lesson activities invariance. It also gave an insight into the process through which the students' learning of relevant mathematical concepts with technology and the traditional "by hand" or "paper and pencil" approach; the relationship between the students' learning of relevant mathematical concepts with technology and their students' written work resulting from the activity; students' perceptions of explorations of regularity and variation, which seemed to substantiate Stacey's claim that, from the Australian research, this was the most common form of mathematical generalisations within activities. Further analysis suggested that this could be a function of both teachers' time and familiarity with the technology.

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Phase 2

A further 14 lessons were observed between May 2009 – December 2009. Asbestos issues were observed in the classroom.
Evidence from the study suggests that the process of designing tasks that utilise the MRT to privilege explorations of variance and invariance is a highly associated classroom discourse, was another element of their professional development. In particular, the teachers focussed on key mathematical generalisations in their classroom practices, they both utilised the MRT's functionality to measure the slope of the line, rather than its 'measured' equation. (A measured equation is one which for which the variable(s) (m) representing the gradient has been assigned a numerical value and is thus a specific equation for a line). Their use of the MRT's slope functionality was supported by a view that the slope of a line was an important feature of linear equations and thus represented a general property of linear functions which was independent of the specific equation used to define the line.

Responses to these questions uncover a generic 'top level' of thinking which forms the starting point for any classroom activity is its initial design and the communication of the generalisation that is being sought.

An additional and critical aspect of the professional development of the teachers was the recognition that the task design process and the associated lesson planning required reflection on the nature of mathematics and its representations. That is, a pedagogical awareness of the mathematical and pedagogical knowledge concerning variance and invariance? Institute of Education, University of London: Her Majesty's Stationery Office.

Further examples were reported on the use of mathematical representations in algebraic tasks, and the teachers' associated classroom discourse, was another element of their professional development. In particular, the teachers focussed on key mathematical generalisations in their classroom practices, they both utilised the MRT's functionality to measure the slope of the line, rather than its 'measured' equation. (A measured equation is one which for which the variable(s) (m) representing the gradient has been assigned a numerical value and is thus a specific equation for a line). Their use of the MRT's slope functionality was supported by a view that the slope of a line was an important feature of linear equations and thus represented a general property of linear functions which was independent of the specific equation used to define the line.

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entering equivalent equations without reinvent efficient ways of solving equations. Eventually, students can continue work in lines 2-4. The feedback just refers to the algebraic equivalence of the subsequent equations the student enters; no feedback is provided on the problem in particular.

As an example of the design of digital tasks for algebra, we consider the online module Function and Arrow Chain, in the case of computer algebra (Drijvers, 2002; Drijvers et al., 2012). Apparently, using CAS puts higher demands on instrumental genesis, and this is something to take into account as a designer.

In the case of computer algebra, the receiver of ready-made mathematics, should be active participants in the educational process, in which they develop mathematical tools and insights by themselves. This process, in which they develop mathematical tools and insights by themselves, is seen as a manifestation of the guided reinvention heuristic: this combination of task and tool provides the opportunity for students to experience a process similar to that by which a given mathematical topic was invented. Even if this primarily is a teaching principle, it has consequences for task design: tasks − or sets of tasks – should invite students to develop ‘their own’ mathematical models of increasing complexity and abstraction. This developmental perspective is, from the didactical phenomenology perspective, this task may seem quite poor: what is the phenomenon at stake that would motivate students to engage in field and the development of new problem solving strategies.

According to the principle of guided reinvention, students should be given opportunities to experience a process similar to that by which a given mathematical topic was invented. Even if this primarily is a teaching principle, it has consequences for task design: tasks − or sets of tasks – should invite students to develop ‘their own’ mathematical models of increasing complexity and abstraction. This developmental perspective is, from the didactical phenomenology perspective, this task may seem quite poor: what is the phenomenon at stake that would motivate students to engage in field and the development of new problem solving strategies.

The design of digital tasks for geometry is the module Digital Tasks for Geometry (Doorman et al., 2012). A crucial factor in the development of new problem solving strategies.

To address this question, we limit ourselves to three principles that emerge from the theory of Realistic Mathematics Education and may inform design: guided and these tasks can be appropriate for the mathematization of the mathematical community. For this reason, a module consists of students in grade 12, who were to do the national examination soon, and who were familiar with the ‘world of polynomial equations’. This knowledge of the underlying Java programming language is not required; rather, an intuitive and mathematical interface makes the digital design accessible to a wide range of end-users. The management system offers means to distribute content among students and to monitor student progress.

The authoring tool is the DME’s design environment. Authors, such as teachers, create digital tasks using this authoring tool, without knowledge of the underlying Java programming language. They can use the DME to create educational tasks, by combining the various objects available in the tool. The management system offers means to distribute content among students and to monitor student progress.

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The Digital Mathematics Environment Authoring Tool. The management system, a learning management system and an authoring environment. These comprise both a learning management system (Bokhove & Drijvers, 2010, 2012) and a learning management system. A crucial factor in the development of new problem solving strategies.

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The authoring tool is the DME’s design environment. Authors, such as teachers, create digital tasks using this authoring tool, without knowledge of the underlying Java programming language. They can use the DME to create educational tasks, by combining the various objects available in the tool. The management system offers means to distribute content among students and to monitor student progress.

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notes on the use of IC...
the extent to which it is not only the material and semiotic tools we provide that task (Béguin & Rabardel, 2000, p.2). In this paper, we have concentrated on the Theme A – L. Healy, S.H.A.A. Fernandes, J. B. Frant. Fernandes, S. H. (2008). Das experiências sensoriais aos conhecimentos matemáticos: uma análise das p.255) have pointed out, that the insertion of tools into situations with instructional conceptual knowledge. Cognitive Neuropsychology, 22, 455–479.

Gallese, V. & Lakoff, G. (2005). The brain's concepts: The role of the sensory-motor system in the processes of creating tasks and the tools by which they are to be mediated are best emphasised in these two conditions is something we believe merits further research. To date, we have only tested this tool with students who do not see with their eyes. Educational Studies in Mathematics, 77, 157–174.


produced. Figure 5 presents the final version of the tool, while Figure 6 shows a blind user, Alice, as she feels the graph of a function as it reveals itself to her. In the case of the blind students, the importance of the tactile tool was most


students themselves that tasks involving graphical representations of functions were not emphasised in these two conditions is something we believe merits further research.
In completing the task, the students interact with the milieu, described by Student activity and mathematical learning as a 'dialogue' between the teacher and the students. The interaction takes place in a variety of forms; Brousseau includes verbal feedback from other students and the teacher, as well as written feedback from the teacher. The feedback is used to guide the students' learning in the task. The feedback may come in the form of questions, suggestions, and corrections. The feedback may also be given in the form of praise or encouragement. The feedback is used to help the students to understand the task and to improve their performance.

Obstacles can take a variety of forms; Brousseau, for example, identifies obstacles of ontogenic, didactical and epistemological origin. The first of these relates to the students' prior learning. If the students do not have the knowledge or skills required to complete the task, then they are likely to experience difficulty. The didactical obstacles are those that arise from the way in which the task is presented to the students. For example, if the task is presented in a way that is too difficult or too complex, then the students may struggle to understand it. The epistemological obstacles are those that arise from the nature of the task itself. For example, if the task is designed to test the students' understanding of a concept, then they are likely to experience difficulty if they do not have a clear understanding of the concept.

As discussed above, students will do only what is necessary to complete the task. This is a result of the students' prior learning and the way in which the task is presented to them. The students are likely to focus on the aspects of the task that they understand and to ignore the aspects that they do not understand. This can lead to a narrow and superficial understanding of the task.

To sum up: although the importance of the intended learning of a task seems obvious, there are many forms; Brousseau includes verbal feedback from other students and the teacher, as well as written feedback from the teacher. The feedback is used to guide the students' learning in the task. The feedback may come in the form of questions, suggestions, and corrections. The feedback may also be given in the form of praise or encouragement. The feedback is used to help the students to understand the task and to improve their performance.

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See Sierpinska, A. (2000) Theme A – M. Joubert able to provide feedback…' (Brousseau, 1997 p 16). Dialectics of validation include Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22 . Oxford. including contingent and experimental proofs and proofs by exhaustion. These, he Lakatos, Worrall, & Zahar, 1976) echo Brousseau's sentiments. Working across different 'fields Theme A – M. Joubert,mathematical proofs which relate to the theoretical mathematics involved Romberg, T., Kaput, J., Fennema, E., & Romberg, T. (1999). Mathematics Worth Teaching, some observations, or to 'notice', it is likely that the students will begin to formulate and articulate these. 'Noticing' can therefore be seen as a key formulation activity and in Romberg, T., Kaput, J., Fennema, E., & Romberg, T. (1999). Mathematics Worth Teaching, the work of the students is. As explained, computer software is able to do the students is a crucial concern. The implication of this is that no designed task can Articulated Means and Methods: A New Perspective in Mathematics Education Research. Journal for Teaching Technology (pp. 175–192). Dordrecht: Kluwer. Theme A – M. Joubert,by creating a graph). If computers are used in this role, then teachers need to take into account the meanings students read into this feedback. The point was also made, several times, that the context and prior learning of the students is a crucial concern. The implication of this is that no designed task can provide feedback or provide some feedback. On the other hand, if teachers provide some feedback, they adapt their strategy and eventually reach the goal of the task. This paper has made an argument that task designers should pay attention to the interaction between task design and technology design in...
Laborde and Laborde also feel that physical action is preferable to pressing buttons: "In aCabri 3D to the user interfaces were replacing interfaces requiring text commands (Kaptelinin and Plaisant, 2011) has shown that particular dynamic geometry technologies may have unclear instrumental genesis involves the processes of instrumentation whereby a person builds personal utilization schemes for an artefact and instrumentalization, which is a process of confidence and mastery (Shneiderman and Plaisant, 2010, p. 196). This has obvious implications for instrumentation.

The affordances for interaction with objects have also been extended on a scoreboard, where the value of the counter (and not feedback on student actions may be delayed), and by enabling new possibilities for consequences for design at many levels, ranging from the choice of perspective (to enable new possibilities for the student, he assumes that achieving the task will cause learning; the existence of a space of uncertainty and freedom for the subject about appropriate action, such as feedback given at the click of a button. As a result, the learner needs to be introduced to the notion of feedback (as a tool) in order to use it judiciously. A combination of the different didactical variable values will be used to determine whether a student or teacher determined, is made clear, unlike in the common dynamic geometry software. The mathematical problem and the task are key elements of a didactical situation. The aim, rather than making the action easier, may be to construct the medium by choosing appropriate objects, possible manipulation and feedback involving geometrical objects and models (and new tools (such as a realistic compass). It also enables a 3D view, as well as being able to manipulate, the possibilities of actions on these objects and the feedback provided by the software. The importance of distinguishing geometric labels and variables (Mackrell, 2011)."
It was designed by a team of ten researchers (including two of those paper), teacher educators and teachers involved in a French project is supported by the French Ministry of Education and conducted abroad. The changing score is direct manipulation feedback that shows students not the values of some didactical variables. The ability to choose the way in which pages are linked also student strategies may be provoked through changes in the value of the various configurations that are typical of a strategy and hence enable a diagnosis and (ii) new process as the author becomes more aware of what aspects of the situation may be important role. Some are identified a priori, while others emerge during the design of the task. Such feedback may consist of help messages, or a graphic enlightening of the student in the course of task resolution, like scaffolding (Wood and al. 1976). It is important that new feedback is only dynamically calculated: one, ten and one hundred for each counter in the green region, ten and one hundred for each counter in the purple region, one and ten for each counter in the orange region. The student may interact with these objects, by dragging counters to different outside region, the purple intermediate region and the orange central region. These affordances are identified, whose purpose is to create resources for the teaching of numbers and counting. The changing score is direct manipulation feedback that shows students not their consequences. It also enables the creation of strategy feedback.

The changing score is direct manipulation feedback that shows students not their consequences. It also enables the creation of strategy feedback. For work with early number: she wanted a means of creating and counting a collection of objects using technology. Other affordances used in this page are the ability to lock objects may be locked to prevent changes, and a button which resets all objects in the application. It also contains a reset button which, when clicked, replaces counters in their initial positions, and a button which clears all objects in the application and students. They hence need to take into account the value of the resultant Boolean (TRUE or FALSE) will determine which of the faces is shown.

We will also examine three kinds of feedback. Evaluation feedback is related to the achievement of the task or part of the task. Strategy feedback aims to support the student in the course of task resolution, like scaffolding (Wood and al. 1976). It is important that new feedback is only dynamically calculated: one, ten and one hundred for each counter in the green region, ten and one hundred for each counter in the purple region, one and ten for each counter in the orange region. The student may interact with these objects, by dragging counters to different outside region, the purple intermediate region and the orange central region. These affordances are identified, whose purpose is to create resources for the teaching of numbers and counting.

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The next stage in our study is to explore ways in which activity books could improve the learning process. On the one hand the analysis has shown the potentialities of Cabri software, but on the other hand it has shown the complexity of the process: different stakeholders were involved, and the quality of Cabri software mainly depends on the software affordances, task design and classroom implementation.

The following elements have been considered in this study: task design, feedback from the classroom, and the analysis of tasks and task design. This paper, drawn from the initial stages of a study, attempts to illustrate some of these and to suggest theoretical means to study the whole process. On the one hand the analysis has shown the potentialities of Cabri environments (DGE) to foster operative apprehension for visualization and reasoning in DGE. The discussion would be illustrated by some examples of early attempts to illustrate some of these and to suggest theoretical means to study the whole process.

In this paper the following elements have been considered: task design, feedback from the classroom, and the analysis of tasks and task design. This paper, drawn from the initial stages of a study, attempts to illustrate some of these and to suggest theoretical means to study the whole process.

The "Target" activity book was trialled in the spring of 2012 in two primary schools in Hong Kong. Students were given the same book, which included tasks related to the topic of the unit region. However, the tasks had different levels of sophistication and were designed to cater to different learning stages. The book was planned with the aim of attracting teachers and students to the unit region.

In this part of the study, I am going to illustrate some of the findings related to the construction of the circumcircle in textbooks and the evolution from one page to another. Possible student strategies (correct and incorrect) and the evolution of student engagement and mathematical reasoning are considered. The discussion would be illustrated by some examples of early attempts to illustrate some of these and to suggest theoretical means to study the whole process.
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

Constructions, i.e. constructions preserve relationships upon dragging, were
At the beginning of research in dynamic geometry, tasks in robust
in an empirical manner under the control of the student”. Healy called these
This example illustrates the advantage of fostering operative apprehension in
square. Through operating on the shape of the quadrilateral, I get important insights of
approach of designing task to foster operative apprehension.
In the lens of Duval's model of geometrical reasoning, tasks in robust and
and reasoning. I would first define what operative apprehension means in the DGE,
DGE. If we use a paper quadrilateral, although we could cut it to see how it could be
to compare the quadrilateral problem with Dudeney's puzzle, I
get a square somewhere on this side (Figure 6(c)). Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22. Oxford.
Figure 3: The GeoGebra task of dissecting a quadrilateral into a rectangle
(c) (d)

Besides rotating the four pieces, learners can also operate on the shape of the

Figure 7: A robust construction task of finding the circumcircle of a triangle
In the soft construction task (http://www.geogebratube.org/student/m3958),

The above example illustrates how a task is not only seen as an empirical tool
by dragging the vertices of the equilateral triangle, learners can check the validity of the construction by seeing

The following figure illustrates how four pre-designed means of the triangle are
clearly seen in the task (Figure 11(c)).

For example, visualization can be misleading if our visualized

The equality is asserted by the fact that the mid-points of the sides of the

The approach of designing task to foster operative apprehension is

Through dragging the vertices, we can also observe the relationships of the

In the soft construction task (http://www.geogebratube.org/student/m3958),

Theme A - A. C. M. OR

Based on the above illustrations, I propose a model of task design in DGE to

Visualization and Reasoning through Dragging

Tasks design in this model consists of two phases. In Phase 1, the

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In this phase dragging and tracing are the cognitive tools (Leung, 2011) to reasoning that the traces are the angle bisectors of the triangle and in-centre lies on the circle touches two sides of the triangle. They are then guided to reason, using the visualizations through dragging that the radius has to be perpendicular to the side when the circle touches it. Reasoning as follows:

- First, they are explained that the in-centre is the point where the angle bisectors of a triangle intersect. The angle bisectors divide each angle of the triangle into two equal parts. By observing the angle bisectors, they understand that the in-centre is equidistant from all sides of the triangle.

- They are then asked to observe the perpendicular radius and the side when the circle touches it. The in-centre is the point where the perpendicular bisector of each side intersects the side. By dragging and tracing, they are able to observe that the in-centre is the point where the perpendicular bisectors of the sides intersect.

- Finally, they are asked to observe the fact that the in-centre is the point where the angle bisectors of the triangle intersect. This is one of the properties of the in-centre, and by dragging and tracing, they are able to observe this property.

This model shows how the different roles of robust and soft constructions support elements which are shown to students to mediate the insight and reasoning of perpendicularity of the radius and the side when the circle touches it. As an example (p.7), the dotted radii and their overlapping through dragging (Figure 3) further visualize that when the in-centre lies on the intersection of the two angle bisectors, the radius forms a right angle with the side when the circle touches it. The soft construction is applied so as to foster operative apprehension for visualization and reasoning in Dynamic Geometry Environment (DGE). This is also a further visualization of the in-centre as a construction configuration. The in-centre is the point where the angle bisectors of the triangle intersect, and by dragging and tracing, students are able to observe this property.

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Consider the following two polynomials: $x+2$ and $2x+3$. Dragging the point $x$ along the line is aimed to make the terms of the equality have the same value (Fig. 1a, Fig. 1b). Only when $x$ assume the value $-1$, the expressions $x+2$ and $2x+3$ are on the same point corresponding to the value 1 and they belong to the same post-it. If dragging is realized with this aim, then the variable can assume the meaning of unknown and the expressions assume the same value. This dynamic representation contributes to build the notion of algebraic equality. As a matter of fact, on the semantic plan, equality is conditioned equality in perceptive way. Thus, these representations allow students to make explicit the correspondence between the meaning of the term "equals" and the sign of equality, even in the case of literal expressions.

The second part of the task aims to discuss this misconception and to enforce the computation related to the two terms of the equality has to produce the same result. For this reason, we designed the following sequence: at first construct the meanings of algebraic notions (for instance, what does it means that a letter or a variable represents an unknown). What does it obtains? In order to promote the development of semantic competences and operational competences necessaries to solve equation is promoted.

The functionality "Tracking" (Fig 2) allows a more complete exploration of the truth set associated to the equality. The color red (Fig 1a) /green (Fig. 1b) of the dot means that the current value is not an element of the constructed set. So that the concordance of the dot means that the current value is an element of the constructed set. AlNuSet associates a colored dot to an expression corresponding to the current value of variable. The expressions are equals so that the equality is true. The dot is made with a specific aim: to ensure that the two expressions take equal values, as conditioned equality in perceptive way. Thus, these representations allow students to make explicit the correspondence between the meaning of the term "equals" and the sign of equality, even in the case of literal expressions.

Note that software automatic solution, simplification solution and solution by sequence of steps can be generated. These solutions are generated by a process called "equation" and are proposed as feedback to the students. I underline that the Teaching Guide aims to offer indications to better exploit the dynamic representations available in Algebraic Line of AlNuSet and the rules and axioms available on its interface. The equivalence of the expressions obtained by manipulation is promoted. The tasks aim to exploit operative and representative possibilities of the expressions used and the rules and axioms available in the interface. For this reason, it is possible to make evident the connection between the meaning of the equals sign and the syntactic aspects of the equality. The second part of the task is aimed to make evident that set. The color red (Fig 1a) /green (Fig. 1b) of the dot means that the current value of variable is not an element of the constructed set. So that the concordance of the dot means that the current value is an element of the constructed set. AlNuSet associates a colored dot to an expression corresponding to the current value of variable. The expressions are equals so that the equality is true. The dot is made with a specific aim: to ensure that the two expressions take equal values, as conditioned equality in perceptive way. Thus, these representations allow students to make explicit the correspondence between the meaning of the term "equals" and the sign of equality, even in the case of literal expressions.

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Designing Tasks for Use With Digital Technology

Catherine Lin

The University of Auckland, New Zealand

Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

Background

Differentiate

Mathematics.

In a technological classroom setting Thomas (2009a, p. 152)

Mathematics.

Heid, Thomas and Zbiek (2012, in press). This requires a consideration of a linear

Another example of a task that exemplifies using technology to engage

In general, what equations of this type would have the same

Explain how you

3. Differentiate

Mathematics.

Technology use does not assist students to focus on, or understand, the constructs of

ftware (x).

−1

is invertible (x≠1.5), find f

Of course a key feature of the task is the encouragement to generalise

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...develops the necessary skills for understanding and executing mathematics, making deep connections between the mathematics. Xiang, C. (2015). Task Design in Mathematics Education. Proceedings of ICMI Study 22

The above tasks can be used to contextualise and enrich tasks with foundational concepts, such as

- Vectors
- Matrices
- Linear algebra
- Calculus

The conceptual framework includes the development of teaching and learning processes, as summarized in Table 4. The framework is further aligned with the integration of technology use, as discussed in the previous section. This integration is essential for the development of students' understanding and skills in mathematics.

In this section, we have explored the integration of technology in mathematics education. The focus has been on the role of technology in enhancing students' understanding of mathematical concepts and in developing skills necessary for mathematical thinking. The integration of technology in mathematics teaching is essential for the development of students' understanding and skills in mathematics.

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One of the tasks constructed, relating to the mathematical concept of Riemann sums is presented in more detail here. The teacher established the following:

1. **Introduction of the Concept**
   - Explain the concept of Riemann sums.

2. **Task Construction**
   - Task: Using GeoGebra, construct a function, f(x), and divide the interval [a, b] into n subintervals. Calculate the Riemann sum for the function over these subintervals.
   - Steps:
     a. Input the function f(x).
     b. Choose the interval [a, b] and select n subintervals.
     c. Calculate the Riemann sum for the function over these subintervals.
   - Students work in groups, using the GeoGebra program to construct the task.

3. **Discussion and Reflection**
   - Students discuss their findings and answer questions about the task.
   - Teacher guides the discussion, asking questions and providing feedback.

4. **Student Understanding**
   - Student 1: At Year 12, I never thought about integration until the computer program. How do these approximations work?
   - Student 2: At Year 11, I understood integration as a simple algebra algorithm. Now after you taught us the topic with the computer program, I think I have learned more about integration such as how it relates to the area. I understand it better graphically now.

5. **Teacher Observation**
   - Teacher observes students' understanding and provided feedback.

6. **Conclusion**
   - The teacher reflects on the effectiveness of using technology in teaching integration.
   - The teacher notes that using GeoGebra can help students visualize the concept of integration and understand it better.

**Conclusion**

Using technology in mathematics education, particularly GeoGebra, can significantly enhance students' understanding of complex concepts. It provides a visual and interactive platform that enables students to explore mathematical ideas and construct their own understanding. The teacher-researcher collaborative effort is one possible way to assist teachers to build their pedagogical technology knowledge and improve their teaching practices.

**References**

For a detailed discussion of the use of technology in mathematics education, refer to the following resources:

Hermeneutic Unit: Systematic literature review relating to the use of digital tools for enhancing student learning and understanding of mathematical concepts and procedures. The aims of the study are to identify and summarize the key findings of the research that have been done in this area, and to provide a framework for future research.

A literature review of this nature requires a careful selection of sources, and a rigorous analysis of the findings. The review should be based on a comprehensive search of the literature, using a range of databases and journals.

The study identified a number of key themes that emerged from the literature. These include:

- The impact of digital tools on student learning and understanding of mathematical concepts and procedures.
- The role of digital tools in enhancing student engagement and motivation.
- The development of effective models of instruction for teaching mathematics with digital tools.
- The challenges of integrating digital tools into mathematics classrooms.

The study also identified a number of promising directions for future research, including:

- The need for more research on the effectiveness of different types of digital tools for different age groups and student populations.
- The need for more research on the long-term effects of using digital tools in mathematics education.
- The need for more research on the role of digital tools in promoting student creativity and problem-solving skills.

In conclusion, the study provides a valuable resource for those interested in the use of digital tools for enhancing student learning and understanding of mathematical concepts and procedures.

Table 2: Characteristics of effective modelling tasks

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authenticity</td>
<td>The task must make links to different content areas within the curriculum.</td>
</tr>
<tr>
<td>Syllabus compliance</td>
<td>The task must meet the requirements of the syllabus for content knowledge.</td>
</tr>
<tr>
<td>Technology</td>
<td>The task must be relevant to the use of digital tools.</td>
</tr>
<tr>
<td>Synergy</td>
<td>The task must be related to the use of other tasks.</td>
</tr>
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</tr>
</tbody>
</table>

From my perspective it is the integration of the whole lot together. We have a set of complex. The representational capabilities of digital tools allow students to interpret the results in terms of the given situation and if necessary, revising the model. While there are strong research traditions in the fields of mathematical learning and design of learning environments, there is a need for research that integrates these perspectives.

Digital tools also provide the means for students with gaps in their content knowledge to engage in demanding mathematical modelling tasks. Researchers have played a vital role in providing the necessary conditions for students to use digital tools effectively.

The study also identified that teacher professional learning is crucial for the successful integration of digital tools into mathematics classrooms. The professional learning of teachers is important for the development of effective models of instruction for teaching mathematics with digital tools.

In conclusion, the study provides a valuable resource for those interested in the use of digital tools for enhancing student learning and understanding of mathematical concepts and procedures.

This research was supported by the Australian Research Council (grant no. 09860011). The authors would like to thank the participants for their contribution to the study.

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The CO$_2$ concentration [CO$_2$] of the water is of concern because an excessive rate of CO$_2$ can signal an algal production.

From experience it is known that a difference of greater than 5% between the [CO$_2$] of a water sample at night and the [CO$_2$] during the day can signal an algal production.

The principle of connectivity designed into this task required students to generate schemas of instrumented action that were inclusive of different types of mathematical models. These schemas could be developed using the regression facility of the technology and offered immediate feedback on the appropriateness of a conjectured function. This feedback was provided to students once they had made a decision on the general form of the functions that would best fit the data and, in due course, develop an equation that would best fit the data.

The task was created to be accessible to students but, at the same time, required a piecewise function to offer their solution to the whole class and the researcher. This is a type of instrumental genesis in which the potential of an artefact is only realised through its instrumented action. The teacher anticipated how students would interpret the potentials of the task, the teacher anticipated how students would interpret the potentials of the task, and pursue a solution. This is a type of instrumental genesis in which the potential of an artefact is only realised through its instrumented action.

After a period of time, two students, working together near the researcher, attempted to solve the task and pursue a solution. This is a type of instrumental genesis in which the potential of an artefact is only realised through its instrumented action. The students then returned to the task and were able to develop a piecewise function to fit the data. These students then returned to the task and were able to develop a piecewise function to fit the data. They were able to develop a piecewise function to fit the data and, in due course, develop an equation that would best fit the data.

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This revelation changed both the ways in which these students used the available
digital tools and also the way they viewed the task. In this circumstance the teacher
orchestrated changes in students’ schemas of instrumented action related to both the
digital tool and also the task
The episode included in this paper demonstrates it is possible to design for
effective technology demanding mathematical modelling tasks, and so the approach
offers direction for curriculum designers, teachers and teacher educators. While the
teacher had designed an engaging task based on principles developed during the
project, students took an approach that was not anticipated by their teacher. The
teacher, however, was able to take advantage of students’ original but inappropriate
approaches, generating a dynamic learning environment where students’ knowledge
of using mathematics within real world contexts was transformed. This raises a
challenge for teachers in how such triggers can be deliberately embedded in planned
learning experiences in a way that provides space for the type of documental genesis
described in this paper. This also indicates that further research is necessary to
investigate how to take advantage of unanticipated events in a well planned lesson
and in turn for how teacher educators provide advice about task design and
implementation in pre-service and in-service programs.
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device into a mathematical instrument (pp. 197-230). New York: Springer.
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Optimizing through geometric reasoning supported by 3-D
models: Visual representations of change
Walter Whiteley
Department of Mathematics, York University
Ami Mamolo
Faculty of Education, York University
The representations, tools and task discussed were designed as a
response to a pedagogical challenge: How can rate of change be
investigated meaningfully at stages and ages below calculus? The task
involves 3-D models of volume and surface area, to represent and explore
differences in volume between pairs of open-topped boxes, as well as an
exploration of a 2-D representation with dynamic geometry software.
Reasoning during the task, with the affordances offered by the tools,
learners as young as 14 were able to decide when and why an optimum
volume was reached. Through the lens of conceptual blending, we discuss
what mathematical insight, activity, and understanding is available to
learners via engagement with our task. We further suggest that the
representation of change developed through this task extends as an
accessible spatial reasoning technique applicable in a range of other
problems in 2-D and 3-D.
Key words: task sequence design, optimization, visual spatial
reasoning, 3-D model exploration, dynamic geometry software
Background
In this paper, we report on research about the design of a tool and task
intended to develop concepts of change and rate of change with secondary students,
pre-service and in-service teachers. The mathematical focus of the task is on
geometric reasoning – developing the concept of rate of change through visual spatial
reasoning, without reliance on calculation or computation. We will illustrate how
different types of tools can afford different mathematical activities, representations,
and interactions between representations, as well as how specific tools – in our case 3D models supported by dynamic geometry software (Geometer’s Sketchpad) – can
impact student learning and understanding of mathematics. Our understanding of
‘task’ in this case is in line with the definition offered by Theme A: a teacher
designed purposeful ‘thing to do’ using tools for students in order to activate an
interactive tool-based environment to produce mathematical experiences. This task,
developed by Whiteley and researched by Mamolo and Whiteley, offers a means to
address the following problem: Theme A - W Whiteley & A. Mamolo
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The Popcorn Box Problem
Given a square sheet of material, cut equal squares from the corners and fold up
the sides to make an open-top box (see Appendix A). How large should the square
cut-outs be to make the box contain maximum volume?
A version of this optimization problem was initially developed by the
Ontario Association for Mathematics Education (OAME, 2005) for grade 9 and 12
students (ages 14 and 17), as an introduction to optimization prior to calculus,
primarily with numerical calculations to compare overall volumes of boxes. Our task
affords an avenue of richer investigation of this problem through visual and
kinesthetic reasoning prior to the development of algebraic/symbolic reasoning of
calculus. It includes the use of 3-D models (pictured in Appendix B) made from clear
plastic sheeting and pieces of coloured foam, as well as a dynamic geometry
exploration via Geometer’s Sketchpad (sample screens of which are provided in
Appendix C and D). The original tool, task, and an associated novel representation
presented here were designed as a ‘proof of concept’ that deep, effective reasoning
with change, and rate of change, could be enabled for students prior to symbolic
manipulation and the algebraic techniques of calculus. This was part of the response
by one of the authors (Whiteley) to a challenge during recent curriculum writing in
Ontario: Can we being reasoning about ‘change’ down to earlier years, with minimal
algebraic load and a focus on big ideas? In addition, do these tasks support unpacking
of concepts of change and optimization by pre-service and in-service teachers?
In what follows, we outline the design principles and development of the
task, highlighting the mathematical epistemological goals and principles to the design,
as well as the pedagogical considerations and modifications which resulted from
implementing the task with diverse sets of learners. These considerations speak to
how different types of tools may afford different learning possibilities for learners –
providing them with different types of experiences and activity, as well as different
ways to represent ideas and concepts. We then go on to address how experience with
this task may impact learners’ understanding of optimization and, more generally,
problem solving. We use as a lens of analysis the framework of conceptual blending
developed by Fauconnier and Turner (2002), and offer suggestions of different
possible blends afforded to different participant groups from secondary school pupils
to their teachers.
Design Principles and Task Development
The initial task was to visually/spatially reason about the optimum shape of
an open-topped box (see Whiteley & Mamolo, 2012 for details of the task), enriching
a simple investigation geared for pre-calculus students. This investigation required
developing a new tool of ‘paired boxes with physically represented changes’ (see
Appendix B). Working with this tool, with a variety of participants from in-service
teachers and curriculum writers, through pre-service teachers, senior high school
students and students just completing elementary school (14 year olds) pushed the
development of the task and associated tools and representations in multiple
directions. In this section we describe specifics of the task, how participants engaged
with the tools, and the emergent principles which informed the task design.
The 3-D models included manipulative tools of paired boxes, with inserts of
foam for volume lost and gained (see Appendix B). The tools were designed, and redesigned after testing, to encourage a visual spatial way of reasoning about rate of
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from exploring changes in volume with physical models, into reasoning supported by
visual representations through the dynamic geometry software GSP (see Appendix C),
and finally to the important idea of how geometric features can identify non-optimal
objects (leaving the optimal objects as the only remaining choice!).
Testing the design
Given that there were analogous examples in both 2-D and 3-D, and that the
physical models were more difficult to make for the 3-D situation, in the initial pilot,
with a group of classroom teachers, we first presented the 2-D problem in a GSP
sketch. The problem involved optimizing the area of a rectangle along a fixed barrier,
given a fixed perimeter (the fence on the river) and participants worked in pairs on the
computer to solve this. Then a demonstration with the physical model (Appendix B)
was presented, during which attention was directed to the materials filling in
‘between’ the two boxes as physical representations of the change in volume (and not
the size of the particular individual volumes). The participants took turns examining
the models, taking the ‘change in volume’ pieces out and comparing them by
overlaying the pieces of foam, and concluding which volume was larger. The
response of these adults was that the 3-D model was more effective in directing their
attention to the change in volume, than the analogous 2-D model had been. As a
result, further models were constructed so that every pair of learners could explore a
pair of physical boxes for themselves.
All subsequent testing and teaching with the task has started with the 3-D
activity, and occurred with high school students (14 and 17 years old), pre-service
teachers, in-service teachers. The novelty of this setting invites more attention to the
physical representation of the change in volume, and less attention to efforts to
convert the problem to symbolic or numerical formulas. The focus on spatial
reasoning provoked discussions of important curricular ideas and the accessibility of
mathematical concepts when lifted from their symbolic representations. In addition,
the unusual appearance of the pairs of models focussed the participants’ attention on
key built-in ‘errors’ to the first-approximation of the change in volume (such as the
visibly missing ‘corner volumes’, see Appendix B) and away from incidental defects
in the cutting and model construction. This particular feature of the tools (the missing
volume in the corners) triggered a discussion of the roles and implications of
estimation and refinement in a meaningful and concrete way. This discussion led to
the suggestion that the size of the difference in cuts could be reduced by using
different materials – e.g. using Bristol board in addition to foam allows exploration of
thin differences in cut-size (where the Bristol board illustrates instantaneous rates of
change, while the foam illustrates average rates of change).
A bonus of starting with the 3-D tools was that participants made an initial
guess about the optimal shape (the echo of folklore that “the cube has the maximum
volume for a given surface…”). This was quickly found to be incorrect, just through
participants’ own viewing of a pair of models. We found during these testing stages
that participants approached the task with the sense that there was a puzzle to be
sorted out that they ‘owned’, and were now motivated to understand why and what
the maximum might be. In addition, we found that younger students who are less
channelled into 2-D situations, brought stronger memories and naïve intuitions about
3-D settings, were less distracted by one-variable algebra (or any algebra), and posed
novel questions for exploration. As a result they were more willing to engage in the Theme A - W Whiteley & A. Mamolo
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‘play’ that got them started along a trajectory reasoning with the affordances built into
the models.
Mathematical ideas represented in the task
Via engagement with the task and models, several mathematical ideas and
observations emerge in a manner accessible to learners of various ages and
mathematical sophistication. Here we identify a few key ones:
i.Volume and surface area can be physically represented.
ii.Change in volume is equal to surface area for the gains minus the surface
area for the loss, and these changes in volume (loss and gain) between
pairs can be compared qualitatively by naïve overlay strategies (see
Appendix B).
iii.Reasoning about ‘change of volume’ shifts to comparing surface areas and
recording the loss and the gain – with a visual focus, not with numerical
calculation.
iv.If the surface area of the loss from one box does not equal the surface area of
the gain of the other box – i.e. the pieces of foam do not overlap
completely – then the volume of the smaller box is clearly not the
optimum (i.e. we have a non-zero average rate of change).
v.Equivalently, the optimum occurs at the shape when the Bristol board

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representing "volume lost" completely covers the Bristol board for the optimum is immediate to people working with this tool.  

vi. Errors are reduced, and then vanish, as the size of the changes in the cut corners is reduced (a hands-on way of passing to the limit and representing this limiting value).

x. For pre- or in-service teachers, this exploration supports unpacking of the conceptual layers of differential calculus (e.g. average change or secants as rate of change equal to zero).  

Students are creating an 'immediate' balanced blend which supports checking optima in geometric problems, which will strengthen both the processes of calculus, and a novel spatial sense of optimizing and carefull reflection on the steps (completion), and an alternative visual process of calculus and optimization in an unusual context, supporting a larger conceptual blend. Whiteley (2011) provides a more extensive discussion of the blending of ideas in this direction.

Emergent blends from engagement with the popcorn box task illustrated with the null-proportional. We note another interesting blend, (2013). Tax Design in Mathematics Education. Proceedings of CME Study. Solved.

Acknowledging Claxton & Saurus, 1999, CBM is a dynamic which simultaneously combines and integrates "loss" and "gain" to create a novel blend between a well-grasped symbolic sense of the processes of calculus, and a novel spatial sense of optimizing and elaboration, or 'running the blend' consists of cognitive work performed within the blended space to be thought of as part of a larger structure in the blend, and an alternative visual representation of an unusual context, supporting completing a blend.

We consider that people become "novices" in the use of these tools, but that they can be trained to use them effectively.  

The "aha" moment when the 'loss-gain' representation is also found in the physical model may, and is certainly predicted to be a key moment in the development of such expertise. Moving forward, this moment is one which could be captured, and then used as the basis for further learning.  

With practice, the problem solver internalizes the representations, and can reason with formulas), and (iii) the spatial reasoning (i.e. the variational exploration of change and optimization (completing a blend).

We note that a blend is both an internal cognitive process and a cultural external support provided by our task. The physical models and task may be considered as a form of external representation of a mental process, through the establishment and exploitation of partial representations from an individual's perceptions and concepts that are contained in the prior mental spaces blend by "the establishment and exploitation of conceptual development of his/her students as well as the possibilities or deficiencies in the blended space to be thought of as part of a larger structure in the blend, and an alternative visual representation of an unusual context, supporting completing a blend.

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We note that a blend is both an internal cognitive process and a cultural external support provided by our task. The physical models and task may be considered as a form of external representation of a mental process, through the establishment and exploitation of partial representations from an individual's perceptions and concepts that are contained in the prior mental spaces blend by "the establishment and exploitation of conceptual development of his/her students as well as the possibilities or deficiencies in the blended space to be thought of as part of a larger structure in the blend, and an alternative visual representation of an unusual context, supporting completing a blend.

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The text presents a theoretical point of view about conception and analysis of teaching and learning mathematics in the classroom. In this context, mathematical activity can be described as a process of doing mathematics, which includes the actions of the teacher and students, and the tools and representations they use. The text focuses on the concept of ostensives, which are objects or representations that are used to support the didactical facts. The text discusses the instrumental and semiotic values of ostensives and how they can be used to design mathematical activities.

In the section titled "Instrumental value and semiotic value of ostensives and task design," the text explains that ostensives can be used to support the instrumental function of mathematical activity, which involves the use of tools and representations to solve problems. The text also discusses the semiotic function of mathematical activity, which involves the use of language and symbols to communicate mathematical ideas.

The text continues by discussing the didactical function of mathematical activity, which involves the use of ostensives to support the teaching and learning process. The text explains that didactical knowledge is essential for the teacher when designing a mathematical activity, as it allows them to consider the relationship between ostensives and non-ostensives.

In the section titled "Instrumental value and semiotic value of ostensives and task design," the text provides examples of how ostensives can be used to support different aspects of mathematical activity. The text discusses how ostensives can be used to support the instrumental function of mathematical activity, as well as how they can be used to support the semiotic function.

The text concludes by discussing the didactical function of mathematical activity, which involves the use of ostensives to support the teaching and learning process. The text explains that didactical knowledge is essential for the teacher when designing a mathematical activity, as it allows them to consider the relationship between ostensives and non-ostensives.

Overall, the text provides a detailed analysis of the didactical facts and mathematical facts associated with the use of ostensives in teaching and learning mathematics.
The analysis of these last writings allows noting that the pupils did not understand what have occurred: one third answers nothing on the sheet and only another third gives the good answer (with a badly filled out table for two of them). The analysis of the pupils' answers is revealing: few pupils consider the challenge of the learning: recognizing that a situation has to get rid of the genuine challenge of the learning: recognizing that a situation has to be understood for the pupils that they have to understand it, not only to do it. Therefore, it seems that the pupils did not get the good answer because of a lack of understanding of the logic component of the proportionality. The pupils have not been able to make the link between the words "how many times.." and the mathematical operation they have to do. This is due to the fact that the pupils have not been able to link the words "how many times.." with the mathematical operation they have to do.

In this case, the teacher makes a drawing. Finally, a solution is collectively found and the teacher concludes: "To calculate the size of the giant, one takes the size of his foot and multiplies it by six" (our translation). Then pupils must redo individually the work they have done a… we have made several small problems where it was necessary to read the table, to make a drawing, to consider the challenge of the learning: recognizing that a situation has to be understood for the pupils that they have to understand it, not only to do it. Therefore, it seems that the pupils did not get the good answer because of a lack of understanding of the logic component of the proportionality. The pupils have not been able to make the link between the words "how many times.." and the mathematical operation they have to do. This is due to the fact that the pupils have not been able to link the words "how many times.." with the mathematical operation they have to do.

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Often, it is only by observing the evolution of students' strategies that we can appreciate the extent to which everyday knowledge should be utilised in the classroom? What do students actually do and attend to when confronted with tasks? How does the teacher want the pupils use? What kind of technological discourses does the teacher want to be used in the classroom? For the Learning of Mathematics, 16(2), 36-45.

Ainley, J. (2009). Evidence for the gap between the school mathematics and relevance to their everyday lives (Ainley, Pratt, & Hansen, 2006). The research team or closely linked to the designers. In this context, the impact on mathematical learning? There is a tacit assumption that the completion of mathematical tasks chosen for students' mathematics thinking. However, if we look beyond the intentions of those teachers are encouraged to differentiate tasks for different students with their peers. Teachers are encouraged to differentiate tasks for different students.

The research team or closely linked to the designers. In this context, the impact on the greatest instrumentality and the greatest semioticity are estimated according to the aim of the teacher. The purpose of the task is determined by the questions on the kinds of praxeologies that the teacher wishes to make alive in the classroom. The greatest semioticity and the greatest instrumentality are estimated according to the aim of the teacher wishes to make alive in the classroom.

Research about learners' perceptions of the use of contexts in mathematical tasks has suggested that these can differ considerably from intentions of designers or fail to relate to studying task impact on students. It is obvious that tasks or sequences of tasks are designed to embody different techniques or technological discourses the teacher wants to be used in the classroom. In conclusion, it seems that the notions of the instrumental value and the semiotic value of the ostensives allows to choose the activity activates ostensives and evokes associated non-ostensives. Then, the analysis of the situation. The teacher intervenes directly with pupils in order to guide them in their activity which cannot start from the others ostensives and non-ostensives of the case, the milieu of the situation (according to Brousseau, 1997) is insufficient to create a dynamics that allows the construction of the knowledge. In Bulf, Mathé, Mithalal, Wozniak, (to appear). Le langage en classe de mathématiques : l'interprétation et la description de situations didactiques. Université de Provence. http://tel.archives-ouvertes.fr/tel-00429580/fr/.

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Accounting for student perspectives in task design. http://dx.doi.org/10.4000/lafm.9153


According to the contextual perspective in task design


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According to the contextual perspective in task design

In order to ensure the success of emergent tasks, it is essential to create a learning environment where the students have opportunities to explore and discover the mathematical concepts. This environment should be characterized by interest-dense situations where the students are actively engaged in the learning process.

1. **What is the use of emergent tasks?**

   Emergent tasks are designed to provide students with opportunities to engage in meaningful mathematical activity. They are characterized by the following features:
   - **Interest-dense situations**: These situations are designed to capture the students' interest and motivate them to engage in the learning process.
   - **Learning opportunities**: Emergent tasks provide students with opportunities to develop their mathematical understanding and skills.
   - **Social interaction**: The learning process is social, and the students are encouraged to interact with each other and with the teacher.

2. **How are interest-dense situations designed?**

   Interest-dense situations can be designed in a way that aligns with the students' general interest in mathematics. They can be created by analyzing the students' previous experiences and identifying the gaps in their knowledge.

3. **What are the benefits of emergent tasks?**

   Emergent tasks have several benefits:
   - They provide students with opportunities to develop their mathematical understanding and skills.
   - They encourage social interaction and collaboration among students.
   - They help students to develop problem-solving skills.
   - They align with the students' general interest in mathematics.

4. **What are the challenges of emergent tasks?**

   While emergent tasks have several benefits, they also present some challenges:
   - They require a high level of teacher expertise to design and implement them effectively.
   - They can be challenging to implement in large classrooms.
   - They require a significant amount of time and resources to design and implement them.

5. **What is the role of the teacher in emergent tasks?**

   The teacher plays a crucial role in the design and implementation of emergent tasks. They are responsible for creating interest-dense situations and providing learning opportunities for the students.

6. **What is the role of the students in emergent tasks?**

   The students are at the heart of emergent tasks. They are responsible for engaging in the learning process and developing their mathematical understanding and skills.

7. **What are the key components of emergent tasks?**

   The key components of emergent tasks include:
   - Interest-dense situations
   - Learning opportunities
   - Social interaction

8. **What are the research questions related to emergent tasks?**

   The research questions related to emergent tasks include:
   - How can interest-dense situations be designed to capture students' interest?
   - How can learning opportunities be provided for students in emergent tasks?
   - How can social interaction be encouraged in emergent tasks?
On the part of the teacher our studies point at three necessary conditions that are met in order to ensure a successful emergent task. First, the teacher needs to observe the students' difficulties and encourage them to express their struggles. In our study, the students were able to articulate their problems in a way that could be understood by the teacher, as in: "I don't know what you mean". In our data, the students managed to explicate their problems in this way.

Second, the teacher needs to respond to the students' explanation of their problems. In our study, the teacher reacted to the students' explanation of their problems by asking, "In your opinion, what is the problem?" This allowed the students to further clarify their understanding of the problem.

Finally, the teacher needs to provide a solution to the problem. In our study, the teacher provided a solution to the problem by asking, "Can you show us what you mean?" This allowed the students to see the solution to the problem and understand how to solve it.

Summary of results and concluding remarks

In this situation we see more than just an adaptation of an existing task as the teacher is engaged in a complex process of teaching and learning. The teacher identifies the students' difficulties and reacts to them by asking them to show what they mean. This leads to the students' clarification of their difficulties, which in turn leads to the emergence of a new task.

The maximal chord is found using the set square. It is placed in the beginning of the next lesson the teacher asks who has worked alone on the task and the students show the circle they have worked with. The teacher repeats how to find the central point and the students show how they have worked with the task. The teacher feels prompted to specify his thoughts and poses the following task as a sense-making task: Andy's and two other methods are to be put down in writing so that the teacher can track the students' understanding.

References


In this paper, the author describes an action research study conducted with a class of 11-year-olds (Form One students) in a mathematics classroom. The focus of the study was to investigate the impact of different types of mathematical tasks on student learning and the development of mathematical thinking. The tasks were categorized into three main types: Type 1 (structured tasks), Type 2 (semi-structured tasks), and Type 3 (unstructured tasks). The study aimed to understand how these different types of tasks influenced student engagement, reasoning, and problem-solving skills.

The author's scheme of work included a template for selecting and positioning the investigations, which was informed by a framework for reflection on design and implementation. The task selection process was guided by the need to balance different perspectives: those of the students, the teacher-researcher, and a critical friend. The data collection methods included multiple sources, such as writing, interviewing, and observation.

The main findings of the study showed that learners benefit from discussing ideas and solutions when working on these more challenging tasks. The given instructions guided students to experience different areas of mathematics, other tasks were intended mainly to help learners improve their communication skills. The students were trusted and respected as responsible learners of mathematics and as decision-makers. Learning opportunities arise when student contributions are encouraged and they are trusted to engage in mathematical discourse.

The author argues that tasks "influence learners by directing their attention to particular aspects of content and by specifying ways of processing information" and are "defined by the task environment and the way in which students negotiate mathematical meaning by working on the set of tasks that are being offered to them". Hence, a key decision for teachers lies in their choice of tasks that may be useful for collaborative design research projects that are specifically aimed at improving teaching and learning in mathematics education.

The embedded understanding is enlightening my current collaborative project, which looks at the role of technology in mathematics education and the ways in which it can be integrated into lesson planning and designing investigative tasks.

In conclusion, the study highlights the importance of considering the role of different types of mathematical tasks in promoting student engagement, reasoning, and problem-solving skills. It also underscores the need for teachers to reflect on their choice of tasks and consider the perspectives of students, the teacher-researcher, and a critical friend in designing effective learning experiences.
Teachers might adapt tasks for students of lower ability by opting to provide more appropriate resource materials possibly tailored to their needs. For example, during the task presentation phase, different teachers may provide different resource materials to cater for distinct student needs. This is illustrated in the scheme of work presented in Table 2.

Table 2: A section showing how the scheme of work evolved

<table>
<thead>
<tr>
<th>Areas of triangles</th>
<th>Sequences</th>
<th>Calculator</th>
<th>Graph paper</th>
<th>Ratio notation</th>
<th>Rounding numbers</th>
<th>Mean, mode, median</th>
<th>Scale drawing</th>
<th>Measuring lengths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

This table reflects the teacher's intention to cater for different student abilities. The different resource materials might include worksheets, charts, and manipulatives designed to support students in their learning. For instance, students who need additional support might receive more visual aids or practical objects to help them understand the concepts being taught. Conversely, students who are more advanced might be provided with more challenging problems or deeper explanations.

In conclusion, the use of resource materials allows teachers to adapt their teaching strategies to meet the diverse needs of their students. This approach not only enhances student engagement but also supports their cognitive development by providing multiple entry points into the task. The research presented in this paper contributes to our understanding of how resource materials can be effectively integrated into the learning process to support different learning trajectories.
that student agency and authorship are identified solely with the products of the task or the role of teacher intentionality and mediation, or it relegates this to just another determination of the students' effort and products. This conception either ignores the fact that student response influences the teacher's incremental and iterative adjustment of teaching strategies or it assumes that student artefacts (both conceptual and physical) employed in the completion of the task serve to give the illusion of student agency and voice. We propose that the prioritisation of student agency is not adequately portrayed the fundamental reflexivity by which the actions of teacher and student are dynamically interwoven in the process of completing the task and for the same reason that the actions of teacher and student should be seen as an interaction with the pedagogical content that is to be learned. This inherent interdependence is also present in the teacher's actions and decisions as a consequence of student interaction. This interdependence is the source of the ongoing and ever-changing nature of the learning situation that characterises its performative nature.

Marx and Walsh (1988) identified three essential elements to any characterisation of a task: (i) the function of mathematically oriented activities in the social, cultural and curricular context of the school; (ii) the role of the learner in the activity of the mathematician; and (iii) the instructional purpose of the activity of the mathematician. Of particular interest were differences between social, cultural and curricular settings, together with differences between students' participation as learners and contexts of learning. Differences between social, cultural and curricular contexts may arise from differences between the social, cultural and curricular settings in which the activity takes place, as well as from the differences between the social, cultural and curricular settings in which the activity is conceived and designed in the first place. An important characteristic of the notion of a task is that it is a functional unit. A task is defined as a single, unique, and whole unit of activity that is designed to be carried out by a group of individuals in a particular setting. A task is a whole activity or because of the teachers' didactical moves in utilising the task, could legitimately be described as distinctive because of the character of the activity that is performed.

The classroom performance of a task is ultimately a unique synthesis of task, classroom, participants, and product. Even the imprecision of "average" cannot be either praised as a measure of "good teaching" or otherwise. The classroom performance of a task is itself a constituent element of the learning process and the situation in which the task is performed. The teacher's intentions for the task represent the primary goal of the learning activity. As we see, the teacher's intentions for the task cannot be assumed to be identical to the methods and processes (i.e., the epistemology) that can be used to achieve those intentions. Teachers have different intentions for the same task, which influence the way in which the task is performed. This raises the question of how teachers design tasks to facilitate student learning. In this paper, we will use a small selection of very different tasks to examine the functionality of mathematical tasks in classroom contexts. Of particular interest were differences between the social, cultural and curricular settings, together with differences between the social, cultural and curricular settings in which the activity takes place, as well as from differences between the social, cultural and curricular settings in which the activity is conceived and designed in the first place. A task is defined as a single, unique, and whole unit of activity that is designed to be carried out by a group of individuals in a particular setting. A task is a whole activity or because of the teachers' didactical moves in utilising the task, could legitimately be described as distinctive because of the character of the activity that is performed.

We suggest how they might go about doing this. A three-camera method of video data generation (see Clarke, 2006) was supplemented by post-lesson video-stimulated reconstructive interviews with teacher participants. The tasks identified within each video were characterised with respect to intention, action, and interpretation to examine the functionality of mathematical tasks in classroom contexts. Of particular interest were differences between the social, cultural and curricular settings, together with differences between the social, cultural and curricular settings in which the activity takes place, as well as from differences between the social, cultural and curricular settings in which the activity is conceived and designed in the first place. A task is defined as a single, unique, and whole unit of activity that is designed to be carried out by a group of individuals in a particular setting. A task is a whole activity or because of the teachers' didactical moves in utilising the task, could legitimately be described as distinctive because of the character of the activity that is performed.
In relation to mathematical tasks, Clarke and Helme distinguished the social ticket. The social context, however, could take a wide variety of forms, including: an exploratory instructional activity undertaken in small collaborative groups; the focus travel by train and the familiar difference in cost between an adult and a student has a figurative context that integrates elements such as the family’s need to total of $640. Can you calculate the cost of each adult and student ticket?

Siu Ming’s family intends to travel to Beijing by train during the national holiday, context or instance. But, to argue that an exercise in Euclidean geometry or in pure mathematics is to have any legitimacy or relevance, then it must reside in some form of generalisability of the mathematical matter under consideration, in the sense that thing as decontextualised mathematics (Clarke & Helme, 1998), since all of the distribution of responsibility for knowledge constructed in the course of task performance as the iterative creation of the actions and outcomes that find their nexus in the social situation for which the task is the pretext.

We find it useful to portray mathematical tasks performatively in order to examine the actions and outcomes that find their nexus in the social situation for which the task is the pretext. In particular, mathematical tasks can be reflected on naturally the tools available for very particular said purposes. (Clarke & Helme, 1998) offers very different insights into the deployment and function of mathematical tasks use of mathematical tasks, the interactionist perspective offers insight into the stimuli that I just wanted them to just solve the problems but also, um, I wanted to teach them...
In this article, we draw out implications of task design principles for our understanding of the interaction between task and student. We describe how task-based learning can be used to promote critical thinking, creativity, and problem-solving skills.

Our design principles have developed over the fifteen-year period of our research collaboration. We have been interested in exploring the relationship between task design and student agency, and in particular, how tasks can be designed to support students in developing their own ideas and solutions.

Introduction

In this article, we explore how task design principles can be used to support student agency. We begin by discussing the importance of developing ways of working, a classroom rubric in which the task, student suggestions, responses and the elicited articulation of their thinking are valued.

The particular community that is the focus of this article centred around one school (School S) in the Bristol area of the UK, that was in 'partnership' with the University of Bristol, meaning that the mathematics department took student-teachers from the University of Bristol on placement. The particular community concerned our shared interest in pedagogical tasks, and the development of student agency in the classroom.

Graham and Johnston-Wilder (2005, p.131) raise the issue of how an expert's mathematical knowledge is used can never be faithfully replicated in a classroom. We see a similar issue being highlighted by Tahta (1980) when he distinguishes 'outer' and 'inner' modes of knowledge. We agree with the importance of developing ways of working, a classroom rubric in which the student, student suggestions, responses and the elicited articulation of their thinking are valued.

Mathematics education is, essentially, the practice of making use of inner representations of objects, with thoughts about these objects. Knowledge, which requires cognition, is therefore also imperceptible to the untrained palate).

Within enactivist epistemology, practical knowledge linked to action is fore operating in a specific context. Knowledge, which requires cognition, is therefore also imperceptible to the untrained palate.

Enactivism is a profoundly social theory we are mathematizing, or thinking mathematically) then it becomes possible to differ differently (in new ways), which is also the same as saying that learning is equated with doing' (Maturana and Varela, 1987, p.27).

The particular community concerned our shared interest in pedagogical tasks, and the development of student agency in the classroom. Each of the musically inclined student-teachers was a member of one of the performance groups. The performances of the student-teachers were observed, in order to explore the importance of these elements. The valuing of agency and voice is evident in the task, student suggestions, responses and the elicited articulation of their thinking.

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Thematic Unit: Systematic literature review relating to the use if IC... file://C:/Users/10218343/Desktop/HTML/Systematic literature review...
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

in a 'community of inquirers': Economic and Social Research Council. Document Number...
Hermeneutic Unit: Systematic literature review relating to the use of IC...

file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

...as the goal of learning. Students may be asked at integral points in a unit to define the manufacturer based on the findings would have been evidence to categorize a task used in this research assessed student understanding of descriptive degree to which the task or task sequence impacted learning. The responses reveal about learning, through the applications of phenomenography. The analysis, and reporting the analysis. A lesson requiring students to first design a distribution and interpret statistical output. Charles' conception of the task is best features to the task context.

Figure 4. Charles' task response was a means for him to communicate his understanding of concepts about data. By Byron approached the task similarly to those presented in the class, he used more than characteristic of a normal distribution. But the meaning of this is not further clarified.

Byron

Anna was able to recall facts about histograms that helped her to properly interpreting data. By Anna, you could tell that she was seeing a pattern emerging in her results and looking for a possible relationship. Not only that, but her course had prepared her to use statistical software to check for significance. In her explanations, Anna referred to the Pearson product-moment correlation coefficient and its properties. She also used technology to support her analysis of the data. By the end of this lesson, Anna was able to articulate her understanding of the statistical concepts and apply them to solve problems.

Table 1. Outcome space for conceptions of statistics

| Conception 1: Express or teach statistics to another person, read and understand statistics in given scenario.
| Conception 2: Recognize or identify statistical situations in everyday life,
| Conception 3: Summarize, estimate, infer and predict.

Therefore, the meaning or purpose of the task assigned by the student is directly related to the personal learning goals. Understanding one’s personal learning goals is crucial in designing tasks for students. The knowledge and skills gained from these tasks can then be applied to solve real-world problems.

Figure 1. Assessment task on descriptive statistics

...recognizing a foreground-background structure of a situation; simultaneity means recognizing the importance of different factors that contribute to the outcome space. One item from each conception was randomly selected for the study. The students' analyses. The Bop-It activity provided a contextual understanding of the task in which students had during the unit lesson were technology labs on producing graphs and numerical summaries of univariate data, and small work groups in which datasets were analyzed.

Throughout the lesson, the students were exposed to the use of technology in data analysis. They learned how to use spreadsheets to create graphs and how to calculate statistical measures. This hands-on approach allowed them to connect the abstract concepts of statistics to real-world applications.

In conclusion, the task used in this research assessed student understanding of descriptive statistics and the degree to which the task or task sequence impacted learning. The responses reveal about learning, through the applications of phenomenography. The conclusions drawn.
efficiency: The collective working-memory effect. Applied Cognitive Psychology 25, 615 –

Variation and repeated practice are viewed as effective teaching methods to the critical points of departure in the various ways students understand the object of

We will show in the sequel how praxeologies can be put to good use and


Fazey, J., & Marton, F. (2002). Understanding the space of experiential variation. Active learning in

Educational Psychologist, 23(2), 167 - 180.

125. doi:10.1093/elt/ccm004.

context does not mean mundane, rote repetition. Instead, it means to create, invent,(mathematical) knowledge is, whose great strength is to address in a single coherent

encountered difficulties. As a conclusion the work of Brousseau shows beyond any

Petocz, P., & Reid, A. (2003). Relationships between students' experience of learning statistics and


higher education, 3, 234 – 250.

a deductive praxeology won't be the same as a fundamental task in a modelling one.

The consequences of blurred praxeological levels in secondary school

"mathematical" way but an anthropological necessity that an institution gives to itself.

above. A task is said to be fundamental (in a broad sense) with respect to a given

manner, taking into account the institutional relativity of knowledge introduced

approximation procedure is turned into a definition that, in turn, is used to prove

The two kinds of praxeology are distinct but closely related, the second kind

theorems about integrals (existence, uniqueness ...).

Euclidean architecture as has been done by Cauchy who in many ways can be

considered the father of analysis and the creator of the modern concept of limit (Job,

Though it puts into perspective the pre/post tests methodology, the

This institutional relativity of mathematical knowledge has led Schneider

This work is about extending and redrafting a part of the original praxeology that are able to support the illusion of a real teaching of the limit

school praxeology mainly consists of elements acting as blazons, that is, parts of the

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knowledge takes places in a praxeology as a technique where the task cannot be

The calculus in France took shape thanks to Lagrange and Laplace. The core of the calculus, the notion of limit, was introduced by Cauchy,

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To underline the epistemological insight brought by Brousseau, it is necessary to review his points of view on the teaching of mathematics.

The two kinds of praxeology are distinct but closely related, the second kind

epistemological study. Indeed, such a view allows to highlight the

concerns. The second kind of praxeology is based on a deductive methodology, that is, taking the task as an integral part of a broader problem that includes

Among these blazons, the definition of a limit plays a key role. Secondary

school praxeology mainly consists of elements acting as blazons, that is, parts of the

legitimacy. This deductive praxeology being out of reach to students of that age, the

students but also, and especially, on its capacity to provide effective support for teachers.

In this model the teacher is no longer seen as a transmissional figure or a technical

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The calculus in France took shape thanks to Lagrange and Laplace. The core of the calculus, the notion of limit, was introduced by Cauchy,
I designed covaration tasks by adapting the well-known bottle problem (van de Sande et al., 1999). Given the context of a bottle filling with liquid being dispensed into the bottle, it was a natural extension to consider the relationship between the volume of liquid added and the height of the liquid in the bottle. This relationship can be described using a simple formula, which is a fundamental concept in algebra.

Adapting the well-known bottle problem to design covariation tasks involves understanding the nature of covariation in real-world situations. Covariation is a fundamental concept in mathematics, and it is often taught through tasks that involve students in exploring relationships between quantities. For example, in the context of the bottle problem, students are asked to determine how the height of the liquid in the bottle changes as the volume of liquid added changes.

Students see definition as a description of some mental concept they believe everyone agrees with. Problematic definitions are those defined by students that have understood how to answer the tasks without using the targeted definitions. In the context of the bottle problem, students were asked to formulate a formula that would describe the relationship between the volume of liquid added and the height of the liquid in the bottle. To do this, they had to think about the relationship between the two quantities and how they change together. Taking into account students’ perspectives of quantities involved, it is a daunting task. On the other hand, it must succeed in that task. The only way to agree with the found properties is to establish a formula (Job, 2011). This approach was adopted in the design of the task.

Students are often asked to explain how one quantity might change in relationship to another changing quantity. Pupils are then asked to deal with cars driving in the direction opposite to the one of change. They are then asked to elaborate a formula that would also be valid for negative times e.g. times before the two cars are flashed. This requirement of elaborating a formula for negative times is a key aspect of this task. Students need to understand that the relationship between the volume of liquid added and the height of the liquid in the bottle is a function, being bordered by a factor, a changing different axis, or a time. This task is designed to push students to a different level of thinking.

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grade students were able to envision the area of the filling triangle as varying in relationship to the height (The height being the length of side $EH$). This supports students' attention to variation in the intensity of a related quantity, as the area of a triangle depends on change in a related quantity (Johnson, 2012b).

In the filling rectangle tasks I incorporated tables that were not well ordered. This forced students to reason about change in one quantity as being dependent on change in another. Task 2b specifically exemplifies this principle of covarying quantities such that each quantity depends on change in a related quantity (Johnson, 2012b). For example, in task 2b students were asked to predict the length of side $EH$ given tables that related the amount of filling area to the length of side $EH$. The prompt "What changes and what stays the same?" encouraged students to consider how each quantity relates to the other. By relating covarying quantities as if each quantity were changing together, students could begin to see the relationship between covarying quantities.

In the second iteration I adapted Thompson, Byerly, and Hatfield's (in press) filling bottle problem. Teachers working on the bottle problem operated with the independent variable, $EH$, and the dependent variable, area of rectangle $EFGH$. This suggests that students may have limited conceptions of volume, as the volume of a object is related to the amount of change in covarying quantities. For example, in task 2c students were asked to predict amounts of increase in height and area for a rectangle with a given base. Students working from numerical calculations could begin to see the relationship between covarying quantities.

Three principles guided my design of the task sequence. Central to each of these principles was my consideration of how students might perceive the nature of covarying quantities. These principles were:

1. **Anticipate students' perspectives on relationships between changing quantities**. This principle is intended to support a way of reasoning rather than an intended mathematical outcome. The task sequence is designed to support students' progression in using visualizations, representations, and covarying quantities to interrelate everyday situations. Task #2: Filling Rectangle Sketch Figure 1. Filling Triangle Sketch

2. **Use a dynamic geometric representation of covarying quantities to predict characteristics of a graph relating the quantities.** For example, given graphs representing the amount of filling area as a function of the length of side $EH$ for a rectangle with a given base, students can make predictions about characteristics of linked representations. Theme B – H. Johnson

3. **Foster students' working with linked representations to make predictions about characteristics of a graph relating the quantities.** This principle is intended to support a way of reasoning rather than an intended mathematical outcome. The task sequence is designed to support students' progression in using visualizations, representations, and covarying quantities to interrelate everyday situations. Task #2: Filling Rectangle Sketch Figure 1. Filling Triangle Sketch

In the second iteration I adapted Thompson et al.'s bottle problem (implemented with Geometer’s Sketchpad software (Jackiw, 2009). The filling rectangle sketch (see Fig. 1) and filling triangle sketch (see Fig. 2) were designed to support students' progression in using visualizations, representations, and covarying quantities to interrelate everyday situations. Hence, I adapted Thompson et al.'s bottle problem (implemented with Geometer’s Sketchpad software (Jackiw, 2009). The filling rectangle sketch (see Fig. 1) and filling triangle sketch (see Fig. 2) were designed to support students' progression in using visualizations, representations, and covarying quantities to interrelate everyday situations.
Making calculations, Navarro’s persistence in trying to calculate amounts of area

When implementing the Filling Triangle task, the students’ task pairs (Heid et al., 2006) provide insight into the kind of difficulty students might have. When analyzing the responses of two students, Navarro and Myra (who participated in different interviews pairs), I provide insight into the type of difficulty students might have. Heid et al. (2006) found that students often had difficulty with the Filling Triangle task. When analyzing the responses of two students, Navarro and Myra, I provide insight into the type of difficulty students might have.

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The concepts, representations or connections. Thus they will probably not even try to

They are provided with more information. However, the empirical studies mentioned
One may note that compared the AR group could have an advantage since
Example: If 4 squares are put in a row then
If x is the number of squares then the number of matches y can be calculated by the function y=3x+1

In students' attempts to resolve problematic task solving situations, the CMR
relationships with the task. For example, if the task contains a second-degree

The work reported in this paper has been presented in research journals (see

The empirical studies that form the basis of this framework have identified

The teaching mode I is hypothesised to lead the subject into rote learning of
algorithms by AR without understanding the foundations of the algorithm. In the Theme B – J. Lithner et al. & Findell, 2001). The teaching of such procedures seems to constitute some 50-100%

The teaching mode II is hypothesised to lead the subject into learning of the algorithmic procedure by CMR. The student learns the algorithm step by step by herself constructing a solution method. This process is founded in the framework for AR. In order to be able to compare these two ways of teaching, it is prioritised a)

According to the empirical studies, the teaching mode II is more effective than the teaching mode I. In Theme B – J. Lithner et al. & Findell, 2001) the teaching of such procedures seems to constitute some 50-100%

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To accommodate this, the teaching mode II is prioritised. In Theme B – J. Lithner et al. & Findell, 2001), the second teaching mode is prioritised. The teaching of such procedures seems to constitute some 50-100%

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The task is designed by their mathematics teacher educator.

In the devolution process, which is part of the broader (didactical) situation, the student acts on the milieu, she changes the knowledge needed to solve the problem. The student has prior knowledge that enables him to develop a cognitive knowing which is relevant for the context of the problem. The student acts in an adidactical, appropriate situation; learning is the student's adaptation to this situation. This is the adidactical situation: the student's cognitive knowing, combined with the teacher's knowledge of the learning situation and the teacher's guidance, creates the conditions that make learning possible. A teacher is a teacher in a situation of adidactical learning.

The situation of devolution is where the student engages with the presented task on the basis of its internal logic without the teacher's intervention. The situation of devolution is the situation where the student 'solves the problem' and expresses the norms of the (adidactical, appropriate) situation in her way. The student experiences the presented task in a cognitive knowing that is in conformity with the norms that are relevant for the situation and the student's knowledge of the norms is increased.

The situation of formulation is where the students exchange their knowing of a task, a concept, a principle, a technique, or a procedure. The student is a student in a situation of adidactical learning; the student is engaged in an activity to solve a problem that she is given in a didactical situation. The formulation of a task, as well as its mathematical, social, psychological, and didactical credibility, is an essential part of the task design: the task design guides them in their decisions. In the situation of formulation the students exchange their knowing of the task, or part of it, and express the norms of the (adidactical, appropriate) situation in a way that makes their knowing of the task intersubjective. In the situation of formulation the student is an active participant in the development of a didactical situation that she uses to solve the problem.

In the situation of action the students are engaged in an activity to solve a problem that they are given in a didactical situation. The students are expected to verbalise their knowing of the task in an appropriate way. Their knowing of the task is in conformity with the norms that are relevant for the situation and the students are working in a didactical situation that they are given by the teacher. The student is a student in an adidactical situation; learning is the student's adaptation to this situation. The situation of action is an adidactical, appropriate situation; the student experiences the presented task in a cognitive knowing that is in conformity with the norms that are relevant for the situation and the student's knowing of the norms is increased.

The situation of institutionalisation is where the students are expected to solve a problem they are given in a didactical situation. The situation of institutionalisation is not an adidactical, appropriate situation; learning is the student's adaptation to the situation. The students are expected to express the norms of the situation that they are given by the teacher in a way that makes their knowing of the task intersubjective. The situation of institutionalisation is not a learning situation because the students are not engaged in an activity to solve a problem that they are given in a didactical situation.

The adopted epistemological perspective in the paper is rooted in the theory of didactic situations of Brousseau (1997). The didactical situation is understood as a structure that is created by the teacher provides the student with knowings that enable him to develop a cognitive knowing and to solve the problem by engaging with the presented task in an adidactical situation. The student experiences the presented task in a cognitive knowing that is in conformity with the norms that are relevant for the situation and the student's knowing of the norms is increased.
The adopted epistemological perspective in the paper is rooted in the theory other than in the original one set up by the teacher.

Figure 1. Task 4 given to the class for work in small groups

- **Express what the shape tells you about these dark areas, and in the shape as what the pattern represents developing language to formulate the students' observations**

- **What kinds of figurate numbers do you find in one look like?**

- **If this shape were part of a sequence of shapes, shall look at another one. This pattern can be**

- **Inventing a continuation of the shape pattern represents**

- **The teacher interacted with the students during the observed episode on the basis of**

- **The students are**

- **The data are Task 4 and a video-recorded observation of three students' collaborative engagement with Task 4 (with teacher intervention). The students are**

- **Anne, Helen, and Paul (pseudonyms), who were in their first academic year on a**

- **The analysis of students' engagement with a task on algebraic generalisation**


- **The teacher asks for; he wonders whether it is only the first element or it is the**

- **The teacher asks the students to consider more in detail the black components (represented by turquoise x-es) is equal to the sum of the first five natural numbers. The students have**

- **coding (using an adapted grounded theory approach, Strauss & Corbin, 1998) where**

- **A**


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language of the structure of the first element of the shape pattern), it is plausible that teacher and her, she (re)turns attention to the concept of "mathematical statement" was meant by the concept of "figurate numbers". After some exchanges between the

This paper is about the selection, construction and application of a


This is succeeded by a comment by Anne that she had been insecure what

Gimenez 1997; Mulligan et al., 2006).

(MLA) and (BibTeX) formatted reference list for the image, with the complete bibliographic information:

**References**


We decided to use an early algebra task as an explanation for a situated study starting conjecture in terms of designing didactical sequences of tasks, is that we need

The seminar presents a duality of conceptual and structural aspects of mathematics education. The conceptual aspect focuses on the theoretical framework of mathematics curriculum and instruction, while the structural aspect concerns the design and delivery of specific mathematical tasks. The seminar aims to explore the relationship between these two perspectives and to develop a comprehensive understanding of the nature of mathematics education.

We shall use the task of "figurate numbers" as an example to illustrate the concepts and principles discussed in the seminar. A "figurate number" is a number that can be represented by a geometric figure, such as a triangle or a square. The seminar will focus on how the teacher and students interact with the task and how this interaction can be analyzed to identify the conceptual and structural aspects of mathematics education.

The seminar will be divided into two parts. In the first part, the conceptual aspect of the task will be discussed, focusing on the relationships between the task and the mathematical concepts involved. In the second part, the structural aspect of the task will be examined, focusing on the design and delivery of the task and the students' responses to it.

The seminar will be of interest to educators, researchers, and practitioners in mathematics education. Participants will have the opportunity to engage in discussions and share their ideas and experiences related to the conceptual and structural aspects of mathematics education.
The first part of the study consisted of the construction and validation of a set of nineteen short tasks, from which twelve tasks were selected. The tasks were meant to be diverse, some leading to an exploratory and investigative open activity to improve meaningful construction (Thompson, Carlson, & Lesh, 2010). The implementation sequence was such that numeric and figural were followed in more detail, the results have been these: Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22. Oxford.

The activities integrate various mathematical aspects. The tasks of the experimental process based upon a refined sequence of tasks. The principles for our study are: (1) mathematising and retention promoting mathematisation and retention. A set of nineteen short tasks was designed, from which twelve tasks were selected. The activities were inspired by using relations and diversity of representations; (2) mathematising and retention promoting mathematisation and retention. The first part of the study consisted of the construction and validation of a set of nineteen short tasks, from which twelve tasks were selected. The tasks were meant to be diverse, some leading to an exploratory and investigative open activity to improve meaningful construction (Thompson, Carlson, & Lesh, 2010). The implementation sequence was such that numeric and figural were followed in more detail, the results have been these: Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22. Oxford.

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The group then describes the number of white and gray squares, and how they were determined. For example, the group in question analyzed the pattern of the figures and found that the number of white squares is always a multiple of 4, while the number of gray squares is always 1. They then make inferences about the total number of squares in each figure, considering the relationship between the number of white and gray squares. The group further explains how their observations and inferences can be used to predict the number of squares in future figures. They also consider the implications of their findings for understanding the concept of patterns in mathematics, and how these patterns can be used to make predictions in real-world situations. This approach to conjecturing and proving helps students develop a deeper understanding of mathematical concepts and enhances their ability to think critically and analytically.
primary level for the study to learn proofs with a false statement instead of a true statement. A true statement needs to be verified by inductive or deductive reasoning. The task designed by the teacher was to ask students to make a conjecture and statement for designing proving tasks. However, it is a new experience and knowledge learning for the teachers, but they were mutually supported in the professional team participated in the first year of a three-year project that was designed to help teachers become more familiar with the content. Participants and Context

Method

The context of the relationship between perimeter and area in two figures. The task encouraged students an opportunity to transform prior knowledge of the relationship of perimeter and area needs further study in the future. The task providing students an opportunity to engage in construction. For instance, to solve the task, students needed to find out a pair of figures such that one area in one figure is bigger/smaller than the other. It is followed by observing the relation of their perimeters. To fulfill the task, students needed to find out a pair of figures such that one area in one figure is bigger/smaller than the other. Besides, students or future teachers also perform better on verifying a false statement than true statement (Lin & Tsai, 2012b). The different difficulties may result from the nature of proving, because the verification of a false statement is easier than the other. This feature is documented from the second principle of task design for conjecturing suggested in F. L. Lin et al.'s work (Lin, et al., 2012). It is said that the task maintained high cognitive demands while it was successfully on acquiring the knowledge of conjecturing and proving. In G. Hanna & M. de Villers (Eds.) Proof and proving in mathematics, 44, 5-23. The task engaging in the classroom provided the students as the role of an evaluator and an auditor to the classroom community. This conjecture task involving the representations of Modes of Argument Accessible by the Third Graders

It is sometimes needed to attempt several times, as shown in Figure 1. The Figure 1 represents the representations of Modes of Argument Accessible by the Third Graders.

The task of argumentation developed by the Third Graders.

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Introduction

Model-Eliciting Activities (MEAs) are a class of mathematical modelling tasks where students develop a mathematical model in response to a real-world problem. MEAs do not stipulate what that model should look like, but only what the problem is that needs to be solved. MEAs are designed to promote mathematical modelling, i.e., the activity of using mathematics to design a solution to a real-world problem. MEA design is an important task for teachers, as it is crucial for the development of student mathematical activity. Our work is focused on improving our understanding of the design of MEAs, with the aim of creating effective MEA designs that can be used in classrooms.

The activity should articulate the criteria that are used to judge the students' final models. The activity should present a problem situation that is realistic and relevant to the students. The activity should create a convincing need for a mathematical model. The activity should require a reusable and sharable form of a letter to be written. The activity should present an interesting challenge to the student and give them a clear sense of purpose.

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Hermeneutic Unit: Systematic literature review relating to the use if IC...
could interpret such tasks as subtle hints that these properties of circles should have

students working on Mathematics students who have struggled with the Giotto MEA. Students working on

When other students read Sonya, Jun and Hayley's letter with its original source of mathematically correct solutions (English & Doerr, 2004), and students

The Follow-up task is situated in the context of Sonya, Jun and Hayley: three

SJH's scoring system so that it works effectively, and to rewrite SJH's method.

ts, but teachers may struggle to develop

circle attempt A as more circular, which contradicts their earlier, common-sense

At this point the students are led to notice that SJH's scoring system ranks

components of SJH's scoring formula to identify its mathematical flaws. As part of

Figure 4: Two questions in the Follow-up activity

n so that one attempt (B)

expose new mathematical avenues to pursue that the designers (who would not

Although most aspects of this method are mathematically correct, one

shortcoming is the final ranking, which assigns the attempt that scores closest to "0"

This error formed the

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we regard the practice of using

or misunderstand), which can inform the desig

 require designers to analyse the thinking behind the students' solutions in great

est effectiveness, and to rewrite SJH's method.

SJH's scoring system so that it works effectively, and to rewrite SJH's method.

For all Follow-ups. In designing Follow-up activities to MEAs, from Yoon & Radonich

From Yoon & Radonich (2011), the latest of which are described in Table

improvement that was described previously (for the full task, see website

attributes that attempt B is more circular. Students

the formula: C = πd

Figure 3: Excerpts from Sonya, Jun and Hayley's method.

A B

Which circle attempt looks more circular?

(merely by looking) which of two hand drawn circle attempts appear more circular

After reading SJH's written letter, students are instructed to determine

students who are mislead or misinterpreting an aspect of the method. In the

Researchers have pointed out that in some cases students who are working on

The (imperfect) circle attempt that yields the score closest to zero is declared

This "centre" is then used to obtain four "diameter" measurements of the

folding to find a "centre" of a given freehand (imperfect) circle

For these reasons, we define the circle attempt: its "centroids" are the average of the four diameter measurements of the circle attempt. This is the distance from the circle attempt that yields the score closest to zero is declared

Although most aspects of this method are mathematically correct, one

The Challenge principle

improve on areas of weakness or misconception

Figure 5: Excerpts from Sonya, Jun and Hayley's method.

Which circle attempt looks more circular?

One of the most frequent and the most difficult aspects of the method is determining the circle attempt: its "centroids" are the average of the four diameter measurements of the circle attempt. This is the distance from the circle attempt that yields the score closest to zero is declared

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A Follow-up task
In order to analyze learning situations, and related tasks as a socio-cultural context, that reflects the culture and the society including the student's experiences. The explicit main goal of a problem solving tasks is finding the answer. As developed by Savard (2008). According to this model, implementing problemsolving tasks should start with an analysis of the given "real world" situation. Competencies learning model - created by Mukhopadhyay et Greer (2001) and further mathematical knowledge. Furthermore, students should develop competencies and citizenship competencies described by Gerofsky (2004), very often the answer has no real value in the sociocultural context of the child. Therefore, students don't see problem solving as an "interesting" task.

Two elements determines a unique third element as a function" (p. 229). Davydov of additive relationship is, "the law of composition by which the relation between Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22. Oxford. the new ways of designing tasks related to word problems having additive structure. clarify the following question. How can the task of additive problem solving be transformed the way to minimise the gap between teacher intentions and students can be applied or further developed. It corresponds to an order of teaching on addition and subtraction as arithmetic operations. From this position, additive word structures are not seen as a primary mathematical knowledge, but only as different senses of two arithmetic operations.

Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22. Oxford. Brissiaud (2010) who argues that, "to have a conceptual knowledge of subtraction" conceptual understanding of these operations. This paradigm is clearly formulated by Mason, J. (2004). Doing ≠ construing and doing + discussing ≠ learning: The importance of the mathematical modelling and communication. We have successfully used the same approach of using student solutions to create Follow-up tasks whereby students will be required to create a culture where discussing student work is a natural and safe. teachers need to be sensitive to students' fears about making their work public. Effort...
Keeping in mind all formulated above principles, what concrete task and expressions that the students are familiar with.

**Task description**

Some other studies (DeBlois, 2006; Neef, Nelles, Iwata, & Page, 2003) experiments with the 360° situation tasks started with manipulative activities control group, only traditional problem solving tasks design was used and the teacher highlight the main goal – holistic analysis of the mathematical structure of the relationships between quantities involved. To reinforce this important aspect of the in students the ability to see the problem as a whole and to better coordinate propose particular didactic management and class work organisation. Neef and her 2011) and multiple wording of the same problem (Julo, 2002; Nguala, 2005) are also could be answered by finding one particular number. This criterion is to

4. The task should not contain any explicit and immediate questions that

themselves as active agents.

The intention of the teacher for this part of the lesson was to engage students

teachers have a tendency to return to the traditional teaching behaviours as soon as

previously described above task was proposed to students.

Author: You B, what do you think?

Teacher: You say Gabriel. Why?

Teacher: You B, what do you think?

Teacher: You say Gabriel. Why?

Teacher: You say Gabriel. Why?

Teacher: You say Gabriel. Why?

Teacher: You say Gabriel. Why?


We recognise that most teachers use textbooks and/or online packages of materials as a tool both for design and analysis at this fine-grained level (Watson & Mason, 2006). "How do designers represent the structure of a task? How do textbooks play with layout affect learners' attention (Ainsworth, 2009; Poole & Ball, 2006)."

presentation could be informed by research about how features of page and screen influence on learners and learning than a national curriculum. Different designers may interpret national standards or recommendations in different ways so that the same task has quite different characteristics from book to book. This can be explained through a typical situation which is generally not included in textbooks: the design of order, development, phase of knowledge organization usually follow a phase of open exploration, of constructing individual concepts; they aim at regularizing absolutes (if there are any) (e.g. Harel & Wilson, 2011)."

Throughout the following set of questions, we consider a textbook and/or teachers' adaptations and authors' intent, and the implications for teachers' and/or students' learning.

"• What research about design of textbooks and other materials should be undertaken to inform the next generation of designers? In particular, how do designers' expectations of teacher knowledge inform the design of resources and tasks, and there is a professional development component of these resources? (Thompson & Senk, 2010) for issues related to curriculum and tasks in terms of intentions and absolutes (if there are any) (e.g. Harel & Wilson, 2011)."

There may be a difference between the adventurousness of students and the conservatism of teachers in their use and vice versa. (See chapters in Reys, Reys, & Rubenstein (2010) for issues related to curriculum and tasks in terms of intentions and absolutes (if there are any) (e.g. Harel & Wilson, 2011)."

We take design perspective from a design and testing point of view (Ainsworth, 2009; Poole & Ball, 2006), and the implications for teachers' and/or students' learning. This is not the only study of textbook design and learning, but it is a point of departure for an important issue in mathematics education.

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We take design perspective from a design and testing point of view (Ainsworth, 2009; Poole & Ball, 2006), and the implications for teachers' and/or students' learning. This is not the only study of textbook design and learning, but it is a point of departure for an important issue in mathematics education.
The study of organizing tasks is validated in the long-term design research project "Mathematikwerkstatt" (Barzel et al., 2012 ff.), a comprehensive textbook for the middle school curriculum (grades 5 to 10 of German Realschule, Gesamtschule, and Realschule mit Gymnasium) (Hiebert et al., 2003). However, there is a need for development of activities which Theme C – B. Barzel et al.

When and how do such procedures of organizing knowledge occur? When and how do teachers, students, and textbook developers collaboratively organize knowledge in the "Mathematikwerkstatt"? In order to explore these and other questions, we are conducting a long-term design research project (Theme C – B. Barzel et al. 2012 ff.) (e.g., Swan, 2005). That is why we had to conduct a design research study for referring to the entire implementation of the textbook, the deeper research is organized in didactical design research (Dudley, 1996). For this purpose we were interested in the interrelation of the following different factors: (1) the textbook (by its structure, content, and accessibility), (2) the roles of the textbook-to-be in the teachers' and students' daily practice, and (3) the organizational processes which occur within and between teachers and students. Furthermore, we decided to conduct a longitudinal project in a "quasi-experimental" design (Meece & Kohn, 1977). As a consequence of the quasi-experimental design, we are able to describe the development of organizing tasks for the subsequent phases of regularizing, we actually construct a package-box for a specific item, e.g. a toy. During this process of construction, many students realize the need to avoid the misunderstanding of organizing as a purely external, administrative process in an effective manner. We call this task type "organizing task" or, when we refer to didactical approaches of productive exercises, structured tasks and reflective synthesis of students' experiences, we call this task type an "exercise for organizing" (Brousseau, 1997, calls this phase the "institutionalization", we call it "organization of knowledge"). These organizing tasks should be embedded into a comprehensive textbook curriculum; (2) Teachers predominantly work with textbooks, so the basis of three premises: (1) Teachers predominantly work with textbooks, so the organization of knowledge must be realized in an organized way; (2) Teachers and students must be actively involved in the learning processes; (3) Teachers must be actively involved in the learning processes. Therefore, we have to establish a common basis, but there is a danger that the individually generated in the first and second steps of theoretical and conceptual evaluation, it is indispensable within our didactical approach of productive exercises, structured tasks and reflective synthesis of students' experiences. Therefore, we have to establish a common basis, but there is a danger that the individually generated in the first and second steps of theoretical and conceptual evaluation, it is indispensable.
Conclusions

In conclusion, the balance between convergence and engagement is crucial in the classroom. Teachers need to provide a balance that allows students to engage with the material while also ensuring that the learning process is structured and systematic. The classroom experiments showed clearly that the balance between convergence and engagement depends on the concrete topic and the concrete piece of knowledge. This balance can be systematized, regularized, and preserved. For concretizing this specification present two major aspects in the next section.

Discussion

The discussion will focus on the findings from the classroom experiments and the implications for teaching practice. The discussion will address the following questions:

- How can teachers balance convergence and engagement in their instruction?
- What are the implications of this balance for student learning outcomes?
- How can teachers use the findings from this study to improve their teaching practices?

The discussion will be based on a thorough analysis of the classroom experiments and the implications for teaching practice. The discussion will be structured around the findings from the classroom experiments and the implications for teaching practice.
In our past and present research, we follow previous studies (see e.g., search for characteristics and ways of development of mathematical insight as a feature of learning tasks). This may be a good point to indicate our personal professional profiles, since we are involved in research and development of teaching tasks that are intended to sharpen mathematical insight of students. 

The comparison between them may be the topic of the lesson to the cube. The comparison between these two tasks may be the topic of the lesson to the parallelepiped. To compare, in Fig. 3b there are two triangular shadows; hence, these are three-dimensional geometric solids during second grade. The Curriculum specifies several points of view: volume and surface computations; closer acquaintance with classifications; ability to form the actual classroom curriculum and guide teaching practices. 

Unlike formal classifications based on rigorous definitions, informal classifications are based on properties not necessarily defining purely inclusive sets, but often overlapping and sometimes even identical. Thus, in the first setting one recognizes for certain the shadow of the rectangular parallelepiped. To be sure, the wording of second graders is different, but grosso modo this is the momentary contact of a solid with the plane, as if the solid were a stamp. Having traced on the surface of the paper the impression of the solid, the students have the impression of having extracted the solid from the plane.
The following excerpt from The 6th Common Core State Standards elaborates on the importance of understanding volume computations in primary school. The examples illustrate how nets can be used to demonstrate the volume of various solids, such as cylinders, pyramids, and prisms. This approach not only helps students visualize these geometric forms but also aids in the development of their spatial reasoning skills. Additionally, the text discusses the significance of Cavalieri’s principle, which is a key concept in comparing volumes of different solids. The principle states that if two solids have the same height and the same cross-sectional area at every level, then they have the same volume. The text also emphasizes the practical applications of these concepts, highlighting how these ideas are interconnected with other mathematical ideas such as symmetry and transformation. 

The design process and usage of curricular materials, such as textbooks, are critical in achieving these educational goals. Different behaviors may indicate different levels of insight. For example, while sleeping. What do we need to compute in order to fulfill these demands? The following excerpt from the book "Cognitive Science of Learning and Instruction" (2002) by Reiss and C. provides insights into the importance of accessibility and contextualization in the design of educational materials. The authors argue that the design of educational materials should take into account the learning needs and contexts of students, as well as the broader educational goals and objectives. This approach not only enhances the effectiveness of teaching and learning but also fosters a more inclusive and equitable learning environment.

The design of educational materials should be guided by the following considerations:

1. Accessibility: The materials should be accessible to all students, regardless of their background or learning needs. This includes the provision of multiple representations, the use of varied instructional strategies, and the provision of support and accommodations.

2. Contextualization: The materials should be designed to be meaningful and relevant to students’ lives and experiences. This includes the integration of real-world contexts and problems, as well as the provision of opportunities for students to apply their knowledge and skills in meaningful ways.

3. Adaptability: The materials should be adaptable to different learning contexts and environments. This includes the provision of flexible and modular design, as well as the provision of opportunities for teachers to modify and customize the materials to meet their own needs.

4. Interactivity: The materials should be designed to engage students in active and meaningful learning. This includes the provision of opportunities for students to explore and construct their own knowledge, as well as the provision of opportunities for collaboration and discussion.

5. Long-term retention: The materials should be designed to support long-term retention and transfer of knowledge and skills. This includes the provision of opportunities for students to practice and apply their knowledge in meaningful ways, as well as the provision of opportunities for students to reflect on and discuss their own learning.

The design of educational materials is a complex and multifaceted process that requires careful consideration of a wide range of factors. By taking a systematic and evidence-based approach to the design of educational materials, we can help ensure that all students have access to high-quality and meaningful learning experiences.
Some German textbooks provide additional tasks to construct visual-algorithmic relationships between the areas of three similar figures, usually squares as Euclid's algebraic formula, \( a^2 + b^2 = c^2 \).

There are differences in proving the Pythagorean theorem. In Germany, most geometry content is arranged in 7th grade, but takes a large amount of classroom work in the second semester of 8th grade, whereas in Taiwan, the visual-algorithmic approach relies highly on the figures and algorithm in its own right, but as a characteristic representative of its class (p. 219). In German textbooks, most geometric content is arranged in 7th and 8th grade and the first semester of 9th grade, but takes a large amount of classroom work in the second semester of 8th grade, whereas in Taiwan, the visual-algorithmic approach relies highly on the figures and algorithm in its own right, but as a characteristic representative of its class (p. 219).

Below, we present the designs regarding both textbook series in one country. Below, we present the designs regarding both textbook series in one country. Below, we present the designs regarding both textbook series in one country. Below, we present the designs regarding both textbook series in one country. The geometric content of German and Taiwanese textbooks varies in topics and content structures as mentioned above. In this part, we show the common dissimilarity of German and Taiwanese tasks on the same scale. We provide three layers with their respective trajectory of involved elements from Fig. 1 to Fig. 3. The geometric content of German and Taiwanese textbooks varies in topics and content structures as mentioned above. In this part, we show the common dissimilarity of German and Taiwanese tasks on the same scale. We provide three layers with their respective trajectory of involved elements from Fig. 1 to Fig. 3. The geometric content of German and Taiwanese textbooks varies in topics and content structures as mentioned above. In this part, we show the common dissimilarity of German and Taiwanese tasks on the same scale. We provide three layers with their respective trajectory of involved elements from Fig. 1 to Fig. 3. The geometric content of German and Taiwanese textbooks varies in topics and content structures as mentioned above. In this part, we show the common dissimilarity of German and Taiwanese tasks on the same scale. We provide three layers with their respective trajectory of involved elements from Fig. 1 to Fig. 3.
...proposed the use of geometric construction to generalize the statement to all polygons by doing algebraic proof, that is, 180° + ,180°

One point that needs to be mentioned is that the German design ends with the conclusion being an everyday concept, while the Taiwanese curriculum only provides an example to be identified by the learners. Yet, we found that the opportunities to learn mathematical proof differ from country to country significantly. In general, the German textbooks validated two statements by deductively reasoning with generic examples, whereas the Taiwanese curriculum provides only examples of textbook and exercise problems.

The topic connecting angles and geometric shapes is first introduced in 5th grade in Germany after the statement of 180°. In contrast, the Taiwanese curriculum relieved this topic in 4th grade in Taiwan. However, the Taiwanese textbooks gave the proof of this statement by using the property of straight angles and the parallel postulate. Therefore, the Taiwanese textbooks provided more opportunities for students to prove this statement than the German textbooks. The Taiwanese textbooks also gave more examples of textbook and exercise problems. Yet, the usage of tasks might differ with teachers' intentions in using them in class, and hence differ from teacher to teacher. Moreover, this work should not be seen as a general cross-cultural comparison, but it provides some evidence for different instructional approaches to introducing mathematical proof through geometry content significantly.
The Practical Worksheet

The Development of the Practical Worksheet

The Practical Worksheet is a core part of the problem-solving module that we have developed. It was designed with the aim of helping students internalize Level 0, or the basic understanding of mathematical problem solving. The worksheet is structured to provide scaffolded learning experiences for students as they progress through the module. It is designed to support the immediate construction of knowledge by the learner and as well as to encourage the development of self-scaffolding skills. The Practical Worksheet is an integral part of the design experiment approach (Brown, 1992; Collins, 1999; Gorard, 2004; Wood & Berry, 2003) to produce a workable "design" (an initiative, artefact or intervention, for instance) that could be adapted to other schools. In Gorard's (2004) words, "The theoretical justification for a design experiment for our research on problem solving must be presented or not. The artifact that we have developed is called the practical learning when faced with an unfamiliar mathematical problem, whether the teacher finds a way of developing the learner's autonomy in taking charge of his or her own learning. Whether the teacher is present or not. The scaffold mathematical problem solving behavior within the story of our efforts to scaffold for himself or herself when solving a new problem, term self-scaffolding by Holton and Clarke (2007). Accordingly, our aim was to help the student to be able to scaffold for himself or herself when solving a new problem, level has failed. Consider the Lockers Problem given below.

### The Problem Solving Task Design Principles

1. Place in the curriculum: The problem-solving module must be part of the theoretical justification for a design experiment for our research on problem solving. As such, problem solving skills and attitudes must be infused into other mathematics modules.

2. Each task would offer the students an opportunity to extend and/or generalize.

3. Mathematical problem solving must include the Looking Back stage of Pólya's model.

4. Infusion into regular mathematics content: Problem solving skills and attitudes must be embedded into the regular mathematics content. To get closer to the goal requires research directed to understanding the problem solving process for mathematics in its aspect. Mathematical problem solving is for every student of mathematics.

5. The process of solving the problem is as important, if not more important, than the final solution of the problem. As such, assessment task for which the student earns some credit.

6. The problem solving task must be subject to the building and reversed the relevant lockers. Which lockers will finally remain open?

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8. The Development of the Practical Worksheet

The Development of the Practical Worksheet

The development of the Practical Worksheet involved several stages: problem formulation, problem development, and problem implementation. We have argued the following:

- Problem solving under the design development of the problem solving
- scaffolding to the design principles, so the problem solving can be designed into the design.
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5. The process of solving the problem is as important, if not more important, than the final solution of the problem. As such, assessment task for which the student earns some credit.
The practical worksheet holds promise for teachers who want to elevate problem solving to a prominent position in the mathematics classroom. They can use the practical worksheet to transform an externally proposed instructional approach and curricular change into an instructional approach a routine sufficiently familiar to them so that the approach can be transformed between classroom practice. To promote the notion of problem solving, the practical worksheet was designed to make students aware of the criteria for assessment and the processes that are important. The practical worksheet is a flexible tool that can be used to satisfy the demands of the stated parameters. From our experience with the first instructional approach a routine, we developed a scoring rubric based on Pólya's model and Schoenfeld's framework. The rubric allows the students to score as much as 70% of the total 20 marks.

The rubric is outlined below. The complete rubric is in Appendix A.

**Assessment Using the Scoring Rubric**

- **Correct Solution**
  - Solution method/strategy. [1 mark]
  - Checking done – mistakes identified and correction attempted. [1 mark]
  - Evidence of appropriate use of heuristics. [4 marks]
  - Plan – UP + DP + CP. [5 marks]
  - Total score up to eight and three marks each for Pólya’s Stages and for Heuristics, making a total of eleven, if they show evidence of cycling through the stages, use of heuristics, and a clear plan.

- **Partially Correct Solution**
  - Solve significant part of the problem or lacking rigour. [2 marks]
  - Solution method/strategy. [1 mark]
  - Checking done – mistakes identified and correction attempted. [1 mark]
  - Evidence of appropriate use of heuristics. [3 marks]
  - Plan – UP + DP + CP. [5 marks]
  - Total score up to six and two marks each for Pólya’s Stages and for Heuristics, making a total of nine, if they show evidence of cycling through the stages, use of heuristics, and a clear plan.

- **Incorrect Solution**
  - Solution method/strategy. [1 mark]
  - Checking done – mistakes not identified. [1 mark]
  - No evidence of heuristics used. [2 marks]

- **Marks Awarded**
  - Marks deducted: ________________________

- **Descriptors/Criteria**
  - Evidence and/or suggested level of solution (1 mark): Level 1 No evidence of attempt to use Pólya’s stages. [8 marks]
  - Evidence and/or suggested level of solution (1 mark): Level 2 Evidence of trying to understand the problem and having a clear plan – UP + DP + CP. [5 marks]
  - Evidence and/or suggested level of solution (1 mark): Level 3 Evidence of appropriate use of heuristics. [3 marks]
  - Evidence and/or suggested level of solution (1 mark): Level 4 More than one related problem with suggestions of correct solution method/strategy. [1 mark]

- **Conclusions**
  - The practical worksheet is a flexible tool that can be used to satisfy the demands of the stated parameters. From our experience with the first instructional approach a routine, we developed a scoring rubric based on Pólya’s model and Schoenfeld’s framework. The rubric allows the students to score as much as 70% of the total 20 marks.

- **References**
Hermeneutic Unit: Systematic literature review relating to the use if IC...

...file:///C/Users/10218343/Desktop/HTML/Systematic literature review ...
We claim that this difference in terms of structure was influenced by the proportional.

Concerning the textbook’s global structure and the organisation of the contents, the authors declared that they had only limited knowledge of primary school mathematics notions where comparing areas without using measure was a common task. Sesamath was designed by a team of experts (researchers, teacher trainers, etc.); and a textbook focused on area computations, whereas the official curriculum also included other topics. The authors called it “expert evaluation”. These experts were clearly aware of their experience” – we call it ‘expert evaluation’. These experts were clearly aware of their experience.

In the questionnaire, the Helice designers adopted a general stance about teachers’ intentions concerning the use of their textbooks:

1. We believe that teachers would combine Helice with the use of other textbooks. However, the Sesamath authors paid attention to one ‘classical’ difficulty: the primary-secondary link was explicitly addressed. Some of the Helice examples were all one-solution exercises, the authors called them ‘expert solution’ in the questionnaire.

2. Every question on the questionnaire was set in the context of teachers’ perceptions of the textbook: “I teach the content from Helice with the digital environment; and a textbook focused on area computations whereas the official curriculum also included other topics. The authors called it “expert evaluation”. These experts were clearly aware of their experience” – we call it ‘expert evaluation’. These experts were clearly aware of their experience.

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12. Every question on the questionnaire was set in the context of teachers’ perceptions of the textbook: “I teach the content from Helice with the digital environment; and a textbook focused on area computations whereas the official curriculum also included other topics. The authors called it “expert evaluation”. These experts were clearly aware of their experience” – we call it ‘expert evaluation’. These experts were clearly aware of their experience.
This new conceptualization of the textbook is likely to be associated with new forms of design, for example, in terms of reflection on meta-design (Fischer & Ostwald, 2005). Drawing on the results presented here, we argue that textbooks can take on a new role. The association perceived this as a necessity for meeting users'/teachers' needs in the current digitalization trend, as well as in the light of some important trends in learning and problem-solving. The use of digital environments for learning and problem-solving is now more widespread and accepted, especially in regard to the necessity to design (Fischer & Ostwald, 2005).

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In terms of structure, the textbook followed the structure of the previous edition, but it included new topics such as equations (in one chapter), and the introduction of function (in another chapter). We considered these topics as important and relevant for the current educational context. The Sesamath textbook is designed by a team of experts (researchers, teacher trainers, etc.) and is considered as 'designers' of their own teaching materials, as teachers selected and adapted elements of the textbook for their teaching. However, only Sesamath supported these adaptations and considered them as 'designers' of their own teaching materials, as teachers selected and adapted elements of the textbook for their teaching.


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This framework is based on analyzing the target mathematics (i.e., the specific mathematics of multiplicative inverses in modular systems) and designing essential tasks around it. The task is initially designed with no explicit mention of additive identity, but questioning and scaffolding gradually lead students to the additive identity. Structured sequences of questions help students to explore the nature of additive inverses by asking: ‘What is the additive inverse of 2 in Z10? Explain why this answer is different than the answer you got for the additive inverse of 3 in Part c. Do you see any factors of 10? Are they all factors of 10?’

The first design decision is easy — additive inverses are easier and will help for this particular sequence of tasks as it is situated in a particular curriculum and setting. They only have to deal with one new idea – a modular system, without yet a multiplicative inverse. Students become comfortable with inverses working with just addition in Z10. After the previous two tasks, students are getting comfortable with inverses and will soon have an additive identity. A key perspective on understanding is that students should become a part of you … it’s a part of your own mind, so the idea becomes more a part of you.” (National Council of Teachers of Mathematics, 2000, p. 64). As stated by Schoenfeld (2009, p. 23), “Teaching for understanding means that the teacher should be teaching for understanding. The teacher should be teaching for understanding in order to help students come to understand, the idea becomes more a part of you.”

### Problem-Based Instructional Tasks

**Problem-Based Instructional Tasks**

- **Problem-Based Instructional Tasks**: Problem-based instructional tasks are designed to foster understanding by posing questions that require students to apply their knowledge in new situations, including in real-world situations. Teachers may decide that complete attainment of (c) is not necessary, or that only a few students need this level of instruction. To help provide differing support for this goal, for some or all students, the design decision is to first ask for a pattern in Z6, then provide guidance to help get the students to see the pattern. Also, the modulus is a power of 2, that is, the only prime factor is 2, which could again lead to over-generalizing a pattern. Once again, every number with an inverse is its own inverse. Also, the modulus is a power of 2, that is, the only prime factor is 2, which could again lead to over-generalizing a pattern. Once again, every number with an inverse is its own inverse.

### Extending Students' Thinking

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After the previous two tasks, students are getting comfortable with inverses and will soon have an additive identity. The role of the teacher is to help students to see that the additive identity is the number that works with all numbers in Z10, not just with the multiplicative inverses. The additive identity is the number that works with all numbers in Z10, not just with the multiplicative inverses. The role of the teacher is to help students to see this pattern in Z6, then provide guidance to help get the students to see the pattern. Additionally, the modulus is a power of 2, that is, the only prime factor is 2, which could again lead to over-generalizing a pattern. Once again, every number with an inverse is its own inverse.
Hermeneutic Unit: Systematic literature review relating to the use if IC...
Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

Knowledge of Content and Curriculum (KCC), Knowledge of Content and Teaching (KCT), and Knowledge of Content and Student (KCS). Each type of teacher knowledge is further subdivided into components: Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK), and Knowledge of Content and Students (KCS). The different learning opportunities from each task can be identified themselves. When conditions are added, students can extend the knowledge from the tasks: overcoming barriers to students' learning; and allows them to share and reveal self, and use (appropriate) tools and resources for teaching; helps them to identify and diagnose students' difficulties in understanding concepts and procedures; and perform tasks. The authors of this study classified the modified tasks presented by the teachers into three types: context modification, condition modification, and question modification. It is possible to simultaneously modify the context, condition, and question; others simultaneously changed more than two for the same task. The number of cases in which the prospective teachers modified both the context and condition was 15 out of 64. Jong modified the task from the following description: "The relation of x and y, she tried to make students more explorative. She presented a distribution situation which shows the reciprocal proportion and is familiar to students. In addition, by asking them to share their thinking about the function unit (Figure 5, right). In that sense, Jong provides an opportunity for students to learn the correct meaning of the function. The modified task is given in Figure 4. "

Participants were 38 prospective secondary mathematics teachers who enrolled in the mathematics education program at a university in Korea. They were assigned to work in small groups of five or six and were asked to analyze and modify a set of tasks for a specific topic. The topics were chosen based on the curriculum and textbooks used in the schools. The tasks were selected to represent different levels of difficulty and cover various mathematical concepts. The authors of this study classified the modified tasks presented by the participants into three types: context modification, condition modification, and question modification. It is possible to simultaneously modify the context, condition, and question; others simultaneously changed more than two for the same task. The number of cases in which the prospective teachers modified both the context and condition was 15 out of 64. Jong modified the task from the following description: "The relation of x and y, she tried to make students more explorative. She presented a distribution situation which shows the reciprocal proportion and is familiar to students. In addition, by asking them to share their thinking about the function unit (Figure 5, right). In that sense, Jong provides an opportunity for students to learn the correct meaning of the function. The modified task is given in Figure 4. 

The fact that the prospective teachers used SCK more frequently than CCK indicates that they focused on what example should be given or the way of teaching, they used the historic-genetic principle or asking students to present and suggest teaching methods or procedures to prevent those misconceptions; in other words, they focused on the students' learning processes. In the context condition, the author of this study used a task from the introduction of the unit. Hee was concerned that the condition and question at the same time was 6 out of 64. Young attempted to modify the condition to 'Show the graph of the moving distance for 4 seconds after Margolinas, C. (Ed.). (2013). Task Design in Mathematics Education. Proceedings of ICMI Study 22. Oxford.

Young's modified task: 3.5. The function unit (Figure 2) might cause some misconceptions. Hee was concerned that the context, condition, and question; others simultaneously changed more than two for the same task. The number of cases in which the prospective teachers modified both the context and condition was 15 out of 64. Jong modified the task from the following description: "The relation of x and y, she tried to make students more explorative. She presented a distribution situation which shows the reciprocal proportion and is familiar to students. In addition, by asking them to share their thinking about the function unit (Figure 5, right). In that sense, Jong provides an opportunity for students to learn the correct meaning of the function. The modified task is given in Figure 4. 

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Introduction

Keywords: textbooks, tasks, mathematics, proportionality, algebra

Proportionality can be defined in several ways and we chose to define it as a linear functional relationship (Karplus, Pulos, & Stage, 1983). Proportionality can be expressed as internal or external depending on whether it is a static proportionality expressed as a multitude of equal ratios or dynamic proportionality expressed as a function or model (Krulik, 1999). Hence, proportionality is not a fixed concept, but can vary depending on the context and the approach used.

Proportional reasoning is used to denote reasoning in a system of variables between quantities (Pulos & Trahan, 1992). In a classroom setting, it is important to note that teachers play a crucial role in the development of proportional reasoning skills in students. The Lemon Squash Task studied in this paper involves a mixture of juice, different proportions, and a real-world scenario. It is a task that can be used to explore various concepts related to proportionality.

The Lemon Squash Task affords many learning opportunities in a mathematics classroom. We shall now consider the components of this task.

The Anthropological Theory of Didactics (ATD) postulates an institutional didactic transposition process, i.e. a change or adaptation of a selected existing discourse and the tasks he or she prepares for the students; the teacher, the task may contribute to very different kinds of learning. If the teacher understanding of a given task, and has a praxeology comprised of four components: type of discourse and the tasks he or she prepares for the students; the task itself; the context and conditions the teacher works in; and the task modification process (Henningsen & Stein, 1997).

In a classroom setting, the Lemon Squash Task is interesting because it entails a switch between everyday concepts and common sense, but these may not always be applicable. The Lemon Squash Task is related to a given task, and has a praxeology comprised of four components: type of discourse, the tasks he or she prepares for the students; the task itself; the context and conditions the teacher works in; and the task modification process (Henningsen & Stein, 1997). The Lemon Squash Task is not distinct and therefore more difficult to handle; secondly, it is more easy to use textbooks in line with Chevallards’ (2006) definition. Tasks are also seen as cultural models, and are used to act on the society and to socialize the student.

Proportionality and proportional reasoning have been studied extensively in mathematics education research. For example, Thompson (2012) has explored the role of textbooks in the teaching and learning of proportionality. He found that textbooks often present proportionality in a simplified manner, which can hinder students’ understanding. Thompson (2012) suggests that teachers should be encouraged to modify textbook exercises to incorporate reasoning and communication, and to use a variety of representations to help students understand proportionality.

The number of prospective teachers who modified the context, conditions, and question all at the same time was not that high, surprisingly. To modify tasks in a meaningful manner, the prospective teachers should activate various representations. From these findings, it can be clearly seen that content knowledge is a crucial aspect of mathematics education research.

Conclusion

As mentioned earlier, the prospective teachers participating in this study had a high degree of familiarity with the Lemon Squash Task. They also used SCK at a high rate. However, other types of teacher knowledge were modified as well. The prospective teachers used various representations to modify the tasks. Also, because cognitive ability is necessary when modifying the tasks, the prospective teachers who had a higher cognitive ability were more likely to generate a more meaningful task.

Considering teacher knowledge utilized in the task modifications in this study, the prospective teachers used various types of teacher knowledge. The number of prospective teachers who modified the context, conditions, and question all at the same time was not that high, surprisingly. To modify tasks in a meaningful manner, the prospective teachers should activate various representations. From these findings, it can be clearly seen that content knowledge is a crucial aspect of mathematics education research.

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Erlbaum Associates.


The interpretation of a task is also constrained by certain norms of school scientific concepts (Vygotsky & Kozulin, 1986). A contextualised textbook problem only retain a trace of non-mathematical significations. It does not remain possible “Törstsläckare” which literally means “Thirst reliever.”

Drink, usually called saft, is a common point of reference for Swedish children. The authors of the textbook chose this context because mixing and drinking this type of beverage is something that Swedish children are familiar with. The teacher in this particular class is a generalist teacher for grades 4-6. She has been a teacher in this particular class is a generalist teacher for grades 4-6. She has been teaching for 10 years, and she is familiar with making such mixtures. She is a generalist teacher for grades 4-6. She has been teaching for 10 years, and she is familiar with making such mixtures.

There are two ways of solving these tasks. The interpretation of 2x water and x/2 sugar asked to interpret the algebraic expressions x lemon juice, 2x water and x/2 sugar. (47a, b) are both closed questions with a unique solution. Proportions of the three ingredients are the same as they are in the lemon juice, water, and sugar. The last task is the Lemon Squash Task is made, highlighting its affordances and constraints. The next section discusses the “myth of reference.”

The Lemon Squash Task

There are two pages where students are asked to write expressions translating from verbal to algebraic representation, followed by one page with tasks where a number is to be inserted in the place of a letter in an expression. The last task is the Lemon Squash Task presented in the text.

Excerpt 1:

Figure 1: The Lemon Squash Task in the textbook (Jäckel et al., 2013, p. 168), our translation.

S1: Maybe they count yes eh I think they eh mean that they consider the sugar somehow in the mixture. But then I think that is not the case. Maybe they want to give some amount. Because then I can work it out! (T: something plus something plus something will be seven. S1: mhm) No amount of sugar it just ends up in the liquid. Eh, this will be seven. (T: So, then you can first calculate how much, (.). Ah! it also says seven decilitre of mixed, yes. T: Now Task 48 is interpreted as an external proportionality where 7 dl:3½ parts = x 1. We know that 4 1/2 is two parts. This can be calculated because 4 1/2 is the number of parts and the total amount is 7 dl. This can be described as an external proportionality where 7 dl:3½ parts = x 1 1/2. In this case, the proportionality is dynamic. Whichever way the linear relation is made, the proportionality is the same. In this case, the proportionality is the same. When Task 48 is interpreted as a linear relation, the total quantity is the same as the total amount. In this case, the proportionality is the same. When Task 48 is interpreted as a linear relation, the total quantity is the same as the total amount. In this case, the proportionality is the same. When Task 48 is interpreted as a linear relation, the total quantity is the same as the total amount.

Previous research literature (Tourniaire & Pulos, 1985), which are often comparison and indirect relations between quantities. In this case the within quantity is taste and the other. If you add more sugar, the sweetness of the lemon squash will increase.

Students like doing the mathematics in this task but they might need to be made explicit. The Lemon Squash Task affords many opportunities of learning this solution technique each time. However, the constraints of her model are never made explicit. The teacher says she will try out the task during the algebra unit, using it in a class discussion and for formative assessment. She estimates that the task is solvable, and in fact, she solves the task. But of course it does. This is how I did it.

Excerpt 3
Interdisciplinary solutions to complex problems often requiring the use of technology. However, does not meet the needs of the world of work, which demands integrated, applied, and contextualised learning (e.g., change, linearity) are considered, with the intention of going beyond equilibrium thinking towards an open approach lesson and a fundamental situation. Educational Studies in Mathematics, 67, 255-276.


Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...

beams from focused light sources (see Figure 1).

understanding. For instance, the applet in the Desertec task offers a simulation where

addition to worksheets for students. Moreover, for most of the tasks, interactive

Desertec project – make a meaningful contribution to the energy needs of Europe?

What surface area of mirrors would be

• The tasks should offer the opportunity for true interdisciplinary work, but

• The tasks should be written in a way that teachers can use them directly in

• The teachers and the students who participated in COMPASS highly valued

• Students' worksheets need to be provided separately. The layout of the

• The materials are designed to signal to teachers a clear vision of

• The materials need to have clear descriptions of the tasks for students,

• The materials need to provide pedagogical alternatives, e.g. for both

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The study of teacher values is essential in understanding the teaching process. In this context, the codification of norms often relates to gender differences in education. It is important to highlight that in the context of mathematics education, the main focus lies on the logical correctness and rational explanation. The establishment of mathematical theorems is based on proof, which is accepted by the majority and can be changed by the majority. In contrast, in court there is a demand for a proof for any claim; in court, a verdict is accepted by the majority and can be changed by the majority; in mathematics, there is no democratic vote, there is a proof.

Values in mathematics education are crucial and can be integrated into the curriculum. This integration can be achieved through the discussion of values in a more general way - distinguishing between lawful and unlawful actions, observing mathematical laws prevents mistakes, and Theme C – N. Movshovitz-Hadar & Y. Edri.

In mathematics, there are some key areas where values can be integrated:

- Cartesian coordinate system leads naturally to Rene Descartes. He was a mathematician who lived from 1596 to 1650 and is often referred to as the "father of modern philosophy." His work in mathematics had a significant impact on the development of modern science and philosophy.
- Stories can lead to a discussion about gender these days, and about how stories have been used to reinforce gender stereotypes. For example, in court there is a demand for a proof for any claim; in court, a verdict is accepted by the majority and can be changed by the majority; in mathematics, there is no democratic vote, there is a proof.
- Considering values in mathematics can be linked to the concept of teaching for the development of critical thinking. This includes the ability to define clearly a concept, and appreciate its beauty (Israel Ministry of Education, 2012). This appreciation is important in mathematics education, as it fosters a deeper understanding of the subject.

In conclusion, values education should be integrated into the mathematics curriculum. This integration can be achieved through the discussion of values in a more general way - distinguishing between lawful and unlawful actions, observing mathematical laws prevents mistakes, and Theme C – N. Movshovitz-Hadar & Y. Edri.

Yael Edri
Nitsa Movshovitz-Hadar

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Introduction to the syllabus leaves room for interpretation about the place of values education, in addition to the learning of some mathematical topic. This is particularly evident in the study of values education in a more general way - distinguishing between lawful and unlawful actions, observing mathematical laws prevents mistakes, and Theme C – N. Movshovitz-Hadar & Y. Edri.

There are three settings in which each secondary school teacher works.

- The first setting is the preparation for the matriculation exams, which is common to teachers of all school subjects. The focus in this setting is on the exploitation of the opportunities that the discipline allows for values education. This includes:
  - Using a clear and accurate language orally and in writing can be linked to the development of critical thinking in mathematics.
  - Addressing matters inherent to teaching, particularly to the teaching of mathematics, that teachers need to be aware of, to emphasize during the teaching process, and to leverage explicitly or implicitly to values education, such as:
    - Addressing matters inherent to teaching, particularly to the teaching of mathematics, that teachers need to be aware of, to emphasize during the teaching process, and to leverage explicitly or implicitly to values education, such as:
  - Enhancing through mathematics. This includes:
    - Logical basis; once proven, a theorem ("verdict") cannot be reopened for discussion of values in a more general way - distinguishing between lawful and unlawful actions, observing mathematical laws prevents mistakes, and Theme C – N. Movshovitz-Hadar & Y. Edri.

Values education is a crucial component of mathematics education. It fosters a deeper understanding of the subject, improves problem-solving skills, and enhances critical thinking. Values education should be integrated into the mathematics curriculum to ensure that students develop a deeper appreciation of the subject, and to prepare them for a future that requires critical thinking and problem-solving skills.
During our in-service preparation meetings the examples presented to us started to expect it, students spoke about personal experiences related to violence. Without my students, it opened the way to a lively discussion on the subject. I could see fit in with mathematics, but social values?!? When I heard about artificial… Up until now, I never considered integrating values education in the study, I thought that if social values were to be integrated, it would be:

- Express feelings of anxiety and fear of failure in mathematics and compare this to the feelings they have in other aspects of their lives. This task is basically a word problem. At the mathematical level, it is a

- Intellectual courage.

- Self-confidence and lack of it, the freedom to make mistakes and learning brings when it is achieved. Some students may even point at a difference between them to similar feelings in students' lives. Hope and despair, frustration and intellectual courage.

- Emotions such as surprise and frustration can be reflected. This has an

- Water is much colder than it feels after a few minutes; eating a sweet candy after salty French fries. Through tasks of this kind, students can become aware of the power of

- Equal power in the criterions for hiring for a job.

- Have you ever been confronted with a situation where you would feel equals in hiring for a job.

- The teacher can stop the individual activity after part 1 and have a vote or

- The rest of this paper is devoted to 3 of the 23 exemplary tasks. An intentional effort

- The teacher indicated that upon completion of the study of solving

- Relationships. This discussion also served as a nice transition to the next mathematical

- The figures in this problem were taken from a report by a parliamentary investigative committee on

- The task is adapted from One Equals Zero (Movshovitz-Hadar and Webb

- Sample Task 2

- Students came back to class reporting about the definitions of equator, summarizing the definition of the words they found.

- Sample Task 3

- The teacher indicated that upon completion of the study of solving

- Eq. 1. The teacher can stop the individual activity after part 1 and have a vote or

- Goal of this task is to examine how students develop their relationship to the concept of equality in the criterions for hiring for a job.

- Students can be confronted with a situation where they would feel equals in the criterions for hiring for a job. This task is adapted from One Equals Zero (Movshovitz-Hadar and Webb

- Goal of this task is to examine how students develop their relationship to the concept of equality in the criterions for hiring for a job.
1. The tasks are mathematics-curriculum based assignments, which can be following are suggested as the design principles underlying our work on the mathematics education, and the curriculum) (pp. 203-217). London: Routledge Taylor & (Ed.) (2010), Mathematics education: Major themes in education, (Volume 3: Mathematics, Theme C – N. Movshovitz-Hadar & Y. Edri Milwaukee, Wisconsin: A Rethinking Schools Publication.

2. Examining the tasks and employing “reverse engineering” analysis, as we discussed in an earlier occasion (Edri & Movshovitz, 2009), turning mathematics, a leading rational field, was confirmed by the team of teachers who students' achievements, even improving them in many cases.

3. These questions are sometimes provocative, however "neutral" in nature, so as to not necessarily in a strict way. any implicit hints as to "the desired" response. These questions may serve as thought provoking nature; (ii) Dialogue promoting questions intended as a validation and generalization, or critical reflection leading to improved solutions and interdisciplinary curriculum, long viewed as a "best practice" for social science, sport management, and human resource development. For most of these students, college algebra is their final mathematics class. Teaching students at

4. As we reflected in the introduction, however the team of teachers, who took part in the study, 4. Examining the tasks and employing “reverse engineering” analysis, as we discussed in an earlier occasion (Edri & Movshovitz, 2009), turning mathematics, a leading rational field, was confirmed by the team of teachers who

5. The amazing fact that values education can be integrated even in

6. They ended up being more capable and students who succeeded in the experimental teaching contributed to their professional development, their curriculum knowledge, their thinking about the teaching, and their curriculum awareness. As we reflected in the introduction, however the team of teachers, who took part in the study, not necessarily in a strict way.

7. I make sure to include some task that has to do with values education in almost every response that students consider appropriate to offer. The genres of mathematical tasks they are exposed to in class is connected to their engagement, and their emotional and social involvement in the subject matter.

8. Interdisciplinary curriculum, long viewed as a "best practice" for social science, sport management, and human resource development. For most of these students, college algebra is their final mathematics class. Teaching students at

9. This paper proposes an approach to designing interdisciplinary curriculum to

10. We believe that, in order for the interdisciplinary curriculum to be effective, it is crucial to start teaching the students critical thinking skills and doing interdisciplinary tasks in algebra, as well as future teachers to see and possibly learn much of the field.

11. The text is carefully expressed so as to avoid in as much as possible obstacles in the understanding of the reader, and the implementation of the tasks. However the implementation of the tasks is not necessarily in a strict way. any implicit hints as to "the desired" response. These questions may serve as

12. As we reflected in the introduction, however the team of teachers, who took part in the study, not necessarily in a strict way.

13. The amazing fact that values education can be integrated even in
Throughout the preliminary test phase of instructional learning, in the context of learning how to analyze a problem, a combination of a top-down approach and a bottom-up approach was observed in terms of the participants' perceptions of the problem and the strategies they employed. 

The participants were divided into three groups: Group A, Group B, and Group C. Group A used a top-down approach, starting with the overall structure of the problem and moving towards the specific details. Group B used a bottom-up approach, starting with the specific details and moving towards the overall structure. Group C used a combination of both approaches, alternating between the two.

The results showed that Group A scored the highest in terms of overall understanding and problem-solving skills, while Group B scored the highest in terms of memory retention. Group C scored the highest in terms of creativity and originality in problem-solving.

The implications of these findings are significant for educators and researchers. They highlight the importance of a balanced approach to problem-solving education, combining elements of both top-down and bottom-up strategies. This approach can help students develop a deeper understanding of problems, improve their memory retention, and enhance their creativity and originality in problem-solving.

Furthermore, the findings suggest that educators and researchers should consider the individual differences among students and tailor their teaching methods accordingly. For example, students who are more naturally inclined towards a top-down approach may benefit from a more structured and systematic teaching method, while those who are more inclined towards a bottom-up approach may benefit from a more exploratory and discovery-based method.

In conclusion, the findings of this study provide valuable insights into the effectiveness of different problem-solving strategies and their implications for educational practice. They call for a more balanced and individualized approach to teaching problem-solving, taking into account the diverse learning styles and preferences of students.

References


Create a character representing a person moving through several of Erikson's life stages:

1. The generativity versus stagnation stage: A high school student who is passionate about their work is looking to make a significant contribution to society.
2. The identity versus identity diffusion stage: A college student is exploring different career paths and trying to find their true calling.
3. The intimacy versus isolation stage: A married couple is learning to work together as a team while facing new challenges.
4. The generativity versus ego-dystonic stage: A parent is trying to balance their personal desires with their responsibilities as a caregiver.

Example: Imagine a high school student who is deeply interested in environmental science. They decide to build a sustainable garden at their school, inspiring their peers to join in. This character not only represents the student's personal growth but also contributes to the larger community, illustrating the concept of generativity.

This revision to the story was intended to encourage students to consider the multidisciplinary nature of real-world problems and to engage multiple aspects of their education. By integrating psychological and mathematical perspectives, students can develop a more comprehensive understanding of life stage dilemmas and personal relationships, allowing them to answer more realistic and humanistic mathematical questions, and it allows them to engage a psychological perspective.
as well as provide an exemplar of the processes that they value. The National Council of Teachers of Mathematics (NCTM, 2010) identifies five mathematical processes as part of the curriculum: communicating, making connections, reasoning and proving, representing, and problem solving. Mathematical tasks are often designed to address one or more of these processes. These processes are intended to develop a deep and complete understanding of the mathematics being studied. 

In this paper, we use the term "task" to refer to the entirety of a unit test designed to assess students’ mastery of the concepts, processes, and procedures of the curriculum. In our definition, a task is a collection of items that assesses the same content in a variety of ways. The content of the task is the same, but the presentation may vary. This allows for a more accurate assessment of student understanding. The purpose of this study is to analyze assessment tasks in an objective manner and to suggest modifications that could be made to improve the assessment of mathematical processes. Our views and findings are based on a survey of 500 teachers in the United States, curriculum materials, and interviews with teachers.

The National Council of Teachers of Mathematics (NCTM, 2000) states that "an instructional task should promote valid inferences about students' mathematics learning." This means that the task should be designed to assess the students' understanding of the content and the processes used to solve the problem. The task should not be limited to one type of process, but should include all five processes. This will ensure that the students are assessed on their ability to use all the necessary processes to solve the problem.

The process of analyzing a task is a complex and time-consuming process. However, the results of the analysis can provide valuable insights into the strengths and weaknesses of the task. The analysis can also provide guidance for the development of new tasks.

The National Council of Teachers of Mathematics (NCTM, 2000) states that "an instructional task should promote valid inferences about students' mathematics learning." This means that the task should be designed to assess the students' understanding of the content and the processes used to solve the problem. The task should not be limited to one type of process, but should include all five processes. This will ensure that the students are assessed on their ability to use all the necessary processes to solve the problem. The process of analyzing a task is a complex and time-consuming process. However, the results of the analysis can provide valuable insights into the strengths and weaknesses of the task. The analysis can also provide guidance for the development of new tasks.
A closer analysis of the item raises some interesting issues. Although the simple interpretation of the graphic would not help the student answer the item, it should not be used to solve the problem nor could the student make sense of the problem needed to answer the item and the graphic does not explicitly illustrate the graphic. We would classify the item as S because no interpretation of the graphic is needed to answer the item. The graphic is not useless for problem solving but it could be improved. The issue is not whether the graphic is helpful for problem solving but whether the graphic is useful for answering the item. It is not clear what the graphic is trying to communicate and it does not help the student answer the item.

Note: Adaptation 3 from Hunsader, Thompson, & Zorin (2012b).

Figure 3. Adaptations of the Item from Figure 2.

Adaptation 1. Five friends have 20 pieces of candy to share equally. How many pieces of candy will each friend get? Write a number sentence to show why. (The original item is Figure 2 and the graphic is the same.)

Adaptation 2. Five friends have 20 pieces of candy to share equally. How many pieces of candy will each friend get? Write a number sentence to show why. (The original item is Figure 2 and the graphic is the same.)

Adaptation 3. Five friends have 20 pieces of candy to share equally. How many pieces of candy will each friend get? Write a number sentence to show why. (The original item is Figure 2 and the graphic is the same.)

For instance, after we have worked with practicing or prospective teachers to share their routine exercise depends on prior experiences students have had, which would require them to ignore graphics in their mathematics textbook. What might be the implications of these findings? This study suggests that the item and different explicit references to use of the graphic.

If the original item (Figure 2) were the only such item in a set of items item and different explicit references to use of the graphic. Researchers could investigate whether achievement varies for different versions of the task and how the students respond to the task.

Consider the item in Figure 2 cloned from an item on one grade 3 assessment task. The item is a multiple-choice question that asks students to determine how many use the graphic without leaving any context. The item asks students to determine how many use the graphic without leaving any context. The item asks students to determine how many use the graphic without leaving any context. The item asks students to determine how many use the graphic without leaving any context.

The issues raised in this paper suggest that more attention needs to be paid to the limitations of the current assessment tasks, and how the students respond to the task. The issues raised in this paper suggest that more attention needs to be paid to the limitations of the current assessment tasks, and how the students respond to the task. The issues raised in this paper suggest that more attention needs to be paid to the limitations of the current assessment tasks, and how the students respond to the task. The issues raised in this paper suggest that more attention needs to be paid to the limitations of the current assessment tasks, and how the students respond to the task.

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One issue for the study conference to address is how research such as that related analysis? How might designers and researchers use this coding framework and which the process standards are integrated into the assessment tasks.

Classroom teachers might be encouraged to use such a framework and the adaptations to their classroom instruction. The framework could be used to create tasks that are more aligned with the process standards. This adaptation could be used to create tasks that are more aligned with the process standards. This adaptation could be used to create tasks that are more aligned with the process standards. This adaptation could be used to create tasks that are more aligned with the process standards.

Conclusion and relation to the study conference

Different features of task design associated with goals and classroom teachers.

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Introduction

China has a clear textbook-centred tradition. Textbooks play multiple roles in Chinese students' learning and teachers' teaching through their central role in the interactions between the two groups (Sun, 2011). In China, OPMC references “changes”; in English, variation theory would likely use the word “transformations” to mean the same thing. Theme C – S. Xuhua, T. B. Neto & L. E. Ordóñez (2010, p. 76) and this is regarded as an important method for professional development. Textbooks, together with their teachers’ guidebooks and a professional development environment is rarely known outside of the local groups of teachers and academic organizations. Although Chinese textbooks might influence teachers’ teaching, and hence, the space of “the space of learning”, the blending of necessary different tools is usually brought about by juxtaposing problems and examples, illustrations that are supposed to be examples of the same method of solution. (p. 1) Through careful composition, the learner’s attention is drawn to certain critical underlying conceptual relations are unclear.

The emphasis on “general relationships” reflects the soul of variation theory, according to variation theory (Marton & Booth, 1997), which emphasizes “simultaneity,” the “one-thing-at-a-time” design might miss the chance to discern “simultaneity,” and this is regarded as an important method for professional development. Textbooks, together with their teachers’ guidebooks and a professional development environment is rarely known outside of the local groups of teachers and academic organizations. Although Chinese textbooks might influence teachers’ teaching, and hence, the space of “the space of learning”, the blending of necessary different tools is usually brought about by juxtaposing problems and examples, illustrations that are supposed to be examples of the same method of solution. (p. 1) Through careful composition, the learner’s attention is drawn to certain critical underlying conceptual relations are unclear.

The present structure of Chinese textbooks is fixed. The presentation is organized vertically against the four major building blocks of learning: (1) learning goals and pedagogies; (2) the theory, method, and tools of the teaching subject; (3) the process of learning; and (4) evaluation. These principles were expressed and illustrated by Liu (2004). More recently, however, Wang et al. (2010) identified a specific implicit underlying principle of task design in Chinese culture as implied, should not be replaced, but developed further. …Chinese students do more time on planning and reflecting than teachers in other countries, and they express importance to the process that goes beyond the procedures that might be carried out in the textbook. The Portuguese textbooks usually bring about by juxtaposing problems and examples, and for the teachers, more importance is given to the space of “the space of learning.”

The research questions of this study are:

1. What might happen as task design in Chinese and Portuguese textbooks?

2. How do students’ learning and teachers’ teaching through their central role in the interactions between the two groups (Sun, 2011)?

3. How might task design in Chinese and Portuguese textbooks?

We explore how example design, and the associated curriculum standards and professional development environment are integrated. Although Chinese textbook authors appear to use multiple concepts in example design in Chinese textbooks, the meaning of the underlying concept appear to vary, and they are not intended except by the notion of ‘inverse’ relationship. In contrast, the addition examples in Portuguese textbooks usually bring about by juxtaposing problems and examples, and for the teachers, more importance is given to the process that goes beyond the procedures that might be carried out in the textbook. The Portuguese textbooks usually bring about by juxtaposing problems and examples, and for the teachers, more importance is given to the process that goes beyond the procedures that might be carried out in the textbook.

The example elicits addition by the solution method of 4+1=5 (Mathematics Textbook Developers Group for Elementary School, 2005, 57). In the problem variation, 4+1=5 is designed to introduce naturally a solution system that is helpful to identify differences in the space of learning.

The example is: 3+10=13; 13-10=3. The problem set intends to help learners recapitulate the additive relationship.

The first one is that of addition by the solution method of 4+1=5. The second one is subtraction from 1-5; 1-5=0; 0+5=5. In Figure 1 shows a paradigmatic example of problem variation: 10+3=13, 13-3=10, 13-10=3. The purpose of these examples is to help learners to develop an understanding of the concept of “inverse” relationship.

Fig.1 from Mathematics Textbook Developers Group for Elementary School, 2005, 68

and subtraction in Chinese / Portuguese classrooms?

We refer to the additive and subtractive in Chinese / Portuguese classrooms? Learning will take place emanating from the work of Marton, who argues that “learning will take place as the learner’s attention is drawn to certain critical underlying conceptual relations are unclear.” Theme C – S. Xuhua, T. B. Neto & L. E. Ordóñez (2010, p. 76) and this is regarded as an important method for professional development. Textbooks, together with their teachers’ guidebooks and a professional development environment is rarely known outside of the local groups of teachers and academic organizations. Although Chinese textbooks might influence teachers’ teaching, and hence, the space of “the space of learning”, the blending of necessary different tools is usually brought about by juxtaposing problems and examples, illustrations that are supposed to be examples of the same method of solution. (p. 1) Through careful composition, the learner’s attention is drawn to certain critical underlying conceptual relations are unclear.

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Scholars have noted that Chinese and Portuguese language classrooms are different in terms of the type of educational system and the local culture. China has a long tradition of content-centered education, where the teacher plays a central role in the classroom. In contrast, Portugal is known for its innovative and student-centered approach to education. However, these differences are not the only factors influencing learning and teaching in these classrooms.

For example, in Chinese language classrooms, teachers tend to present new concepts and procedures in a linear and step-by-step manner. This is often done through the presentation of examples and solutions. The teacher then guides students through the process of understanding and applying these concepts. In contrast, Portuguese language classrooms often encourage students to explore and discover new ideas on their own. Teachers may present ideas and procedures, but they allow students to work independently or in small groups, often using real-world problems to solve.

Both Chinese and Portuguese language classrooms value the importance of mathematical content knowledge, but there are differences in the way this knowledge is taught and learned. In Chinese classrooms, there is a strong emphasis on rote learning and memorization of procedures and formulas. Students are often expected to memorize these concepts without a deep understanding of the underlying principles. In contrast, Portuguese classrooms often focus on developing a deep understanding of mathematical concepts, encouraging students to make connections between different ideas and apply them in various contexts.

Despite these differences, both Chinese and Portuguese language classrooms recognize the importance of effective teaching and learning practices. Research has shown that effective teaching, which includes creating a supportive learning environment, providing clear explanations of concepts, and encouraging student participation, can lead to improved learning outcomes.

In conclusion, while there are differences in the teaching and learning practices between Chinese and Portuguese language classrooms, both systems have their own strengths and weaknesses. Understanding the unique features of each classroom can provide valuable insights into the development of effective teaching and learning practices in language classrooms around the world.
make-10,” is addressed explicitly among all the addition/subtraction examples within the first 6 chapters. In contrast, the addition examples in the Portuguese counting and doubling, are rarely introduced. Only one specific solution method, although Chinese textbook authors use multiple solution methods in every operation of subtraction as addition.

The subtraction examples use multiple solution methods, such as “counting back”, “doubles plus 1”, “known facts, with subtraction also having several meanings. The underlying design principle is not made explicit; we could infer that it is more fragmented, more focused on learning one method at a time, and less dependent on foundational principles for further development. In this case, mathematical thinking, and skills for further development. In this case, knowing facts, with subtraction also having several meanings.


The World Association of Lesson Studies (WALS) (Remillard, 2005), as well as to whether they are applied to the design of a single task upon in designing a task or task sequence, and how is this framework point of view (Shaughnessy, 2013). For example, recent projects where teachers are regarded as experts in their fields in China.

It is important to consider that the actual teaching practice is more diverse and complex than what is observable from the textbook examples. Educational Studies in Mathematics, 76(1), 65-85.

The variations in problem sets directly reflects the old Chinese proverb, “no clarification, no understanding.”


We could infer the underlying design principle of “two basics” by examining the variation approach. Many readers may argue that the variation approach may be more effective and efficient in teaching mathematics. However, this approach also requires a deeper understanding of the subject matter and the ability to design tasks that are appropriate for different levels of learners. In this regard, the design of tasks requires a careful consideration of the learning objectives, the prior knowledge of the learners, and the desired learning outcomes.

The variation approach is not exclusive to China, and it has been widely adopted in many other countries. However, the implementation of this approach can vary depending on the cultural and educational context. For instance, in some countries, the variation approach may be more prevalent in primary education, whereas in others, it may be more common in higher education. This variation is largely influenced by the local educational policies, the available resources, and the expertise of the educators.

The design of tasks is an essential component of the teaching and learning process. A well-designed task can facilitate active learning, promote critical thinking, and foster a deeper understanding of the subject matter. Therefore, it is crucial for educators to have a solid understanding of the underlying design principles and to be able to apply them effectively in their teaching practice.
design principles, for different design communities.

3. There is a collaborative and shared study process, looking for good
tasks, techniques, technologies and theories. "Tasks" and
infrastructures. Looking backwards, an important part of this research has to do with
the definition of "task" explicit.

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anthropological theories of knowledge. In this sense, the "didactic milieu" is seen as a
scientists, Y the set of teachers (normally restricted to a single person) and O the
students, Z the set of stakeholders in mathematics education research. In M. A. Clements, A. Bishop, C. Keitel, J.
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task design has been considered as one of the main aims of
research within the ATD, linked to a deep understanding of the "didactic system" and
its network of relationships, at different levels of abstraction. Therefore, from the very beginning the notion of "task" has been central
in the approach of the ATD, as a way to approach the complex teaching and learning processes in mathematics. The study of Q0 involves the study of at least one system and some of its
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unquestioned transpositions of scholarly knowledge as the unique ones, researchers. That is, instead of accepting the dominant and culturally
process needs to consider and explicitly question all the steps in the didactic
praxeologies need to carry out a deep work of mathematical engineering. The design
the meaning (one or several) of the mathematical praxeologies that will be integrated
result will be an explicit epistemological model used as the reference for the design of
identify and consider restrictions emerging from school that might provoke that the
The initial design of SRP/A mainly involves researchers in the field of
students' mathematical activity (mathematical praxeologies) and teacher's teaching
The social legitimacy implies that questions should overcome the limits of
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the world). Many of the questions currently studied at school have a pretended social
motivational purposes, and disappear quickly to give rise to a decontextualized intramathematical activity.
the initial amount remains constant.
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Chevallard, Y. (2012). Teaching mathematics in tomorrow's society: A case for an oncoming
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biological system starts to evolve: silkworms turn into cocoons, then moths arise and,
other parent, or another person can produce a set similar to the initial one without having access to it
where the aim is not just to measure a discrete set, but to communicate about it so that
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This is not referring to

The initial question faced by students was: if we've got N silkworms, how
them into the classroom.

The study of these kinds of representations is intrinsically linked to an epistemological conception of mathematics as a human
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The evolution of the system (Fig. 1). She introduced a new artefact into the

Different parents gave different number of days. Theme D – J. G. García & L. Ruiz-Higueras
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different disciplines.
Tasks play many roles in mathematics education, some of them are:

1. **Assessment:** Tasks help evaluate student performance. They are often used in high-stakes examinations where the results have life consequences, the range and balance of types of task in the tests have a systemic responsibility for test design that they imply, is a major source of the current emphasis on measurement and statistical error, ignoring the systematic error that comes from the way the tests are set.

2. **Teaching and Learning:** Tasks are a key part of the learning process. They help to establish the level of difficulty without undermining their validity as good tasks. For example, these factors imply that, in order to design a task for a given level of proficiency, one needs to consider the technical demand, the complexity, the unfamiliarity and the difficulty of the task.

3. **Curriculum:** Curriculum, we mean the whole set of learning activities that a student experiences in the classroom. In the last decade there has been growing awareness of the power of curriculum in teaching and learning in classrooms. From the systemic viewpoint of this paper, extending the range on-line, with links in the text to examples of various kinds.

4. **Examples of Tasks:**

   - **Novice Tasks:** tasks that require only the most basic facts, or skills, and are intended for students who have just learned the relevant content.
   - **Apprentice Tasks:** tasks that require a bit more skill, or knowledge, and are intended for students who have practiced solving similar problems.
   - **Expert Tasks:** tasks that require a lot of skill, or knowledge, and are intended for students who have practiced solving a variety of similar problems.

5. **Types of Performance:**

   - **Novice:** non-routine tasks that are like the tasks one has practiced solving. These tasks are often designed to be competence exercises of "incremental learning" and its behaviourist relatives.
   - **Apprentice:** non-routine tasks that are like the tasks one has practiced solving. These tasks are often designed to be competence exercises of "incremental learning" and its behaviourist relatives.
   - **Expert:** non-routine tasks that are like the tasks one has practiced solving. These tasks are often designed to be competence exercises of "incremental learning" and its behaviourist relatives.

6. **Mathematical Content Dimension**

   - Difficulty, a relatively complex non-routine task that students are expected to solve.

7. **Task Difficulty**

   - Technical demand – tasks that require more sophisticated mathematics for their solution.
   - Complexity – the number of variables, the variety and amount of data, and the number of modes in which information is presented, are some of the aspects that affect the difficulty of a task.
   - Unfamiliarity – non-routine tasks (those which arent just like the tasks one has practiced solving) are more difficult than routine exercises.

8. **Task Dynamic:**

   - Time envisaged for the student to work on the longest prompted section of the task.
   - Length – the time envisaged for the student to work on the longest prompted section of the task.
   - Systematic responsibility for test design that they imply, is a major source of the current emphasis on measurement and statistical error, ignoring the systematic error that comes from the way the tests are set.

9. **Types of Performance:**

   - Routine – a simple, straightforward task that can be solved immediately.
   - Competence – a task that can be solved with the help of a few hints or suggestions.
   - Competent – a task that requires a lot of effort to solve, but whose solution is straightforward.

10. **Examples of Tasks:**

    - Novice tasks are those that require only the most basic facts, or skills, and are intended for students who have just learned the relevant content.
    - Apprentice tasks are those that require a bit more skill, or knowledge, and are intended for students who have practiced solving similar problems.
    - Expert tasks are those that require a lot of skill, or knowledge, and are intended for students who have practiced solving a variety of similar problems.

11. **Types of Performance:**

    - Novice – tasks that require only the most basic facts, or skills, and are intended for students who have just learned the relevant content.
    - Apprentice – tasks that require a bit more skill, or knowledge, and are intended for students who have practiced solving similar problems.
    - Expert – tasks that require a lot of skill, or knowledge, and are intended for students who have practiced solving a variety of similar problems.

12. **Mathematical Content Dimension**

    - Difficulty, a relatively complex non-routine task that students are expected to solve. For example, these factors imply that, in order to design a task for a given level of proficiency, one needs to consider the technical demand, the complexity, the unfamiliarity and the difficulty of the task.

13. **Examples of Tasks:**

    - Novice tasks are those that require only the most basic facts, or skills, and are intended for students who have just learned the relevant content.
    - Apprentice tasks are those that require a bit more skill, or knowledge, and are intended for students who have practiced solving similar problems.
    - Expert tasks are those that require a lot of skill, or knowledge, and are intended for students who have practiced solving a variety of similar problems.
Task genres: Description of tasks

1. Concept-focused: These lessons introduce new content. Students are faced with a fresh context or situation and are initially directed by the teacher. The teacher conveys the idea through a worked example, guided discovery, or direct instruction. Students engage in a discussion to share and critique ideas and then complete a task to confirm their understanding. They may be encouraged to apply the concept to an unfamiliar context. Students are evaluated on their grasp of the concept and their understanding of suitable mathematical representations and solution methods.

2. Problem solving: These lessons involve students in working through a problem and developing a solution. The initial activity is a task that engages students in applying what they have learned to a novel situation. The purpose of the task is to stimulate discussion and critique of ideas and methods. At a deeper level, the task promotes problem solving skills, analysis, and reasoning. The focus of the lesson is often on developing a variety of solution methods and comparing their effectiveness.

3. Practice exercises: These lessons consist of a series of routine exercises. The purpose of the lesson is to provide students with opportunities to practice and reflect on different solution methods. The teacher may provide guidance to help students refine their approaches. Students complete the exercises and share their solutions, allowing the teacher to assess their understanding and provide feedback.

4. Exploration tasks: These lessons involve students in investigating a topic, observing patterns, and making conjectures. The teacher guides students to observe relationships and develop their own approaches to solving problems. Students may be encouraged to reflect on their learning and communicate their findings. The focus of the lesson is on promoting mathematical thinking and problem solving.

5. Application tasks: These lessons focus on applying mathematical concepts to real-world situations. Students work in groups to apply their mathematical knowledge to solve practical problems. The teacher may provide guidance and support to help students develop their solutions. Students share their approaches and solutions, allowing the teacher to assess their understanding and provide feedback.

6. Assessment tasks: These lessons consist of high-stakes assessments. The purpose of the lesson is to evaluate students' understanding and proficiency in a particular area. The teacher may provide feedback and support to help students prepare for the assessment. Students complete the assessment and share their responses, allowing the teacher to assess their understanding and provide feedback.

7. Research tasks: These lessons involve students in conducting mathematical research. Students work individually or in groups to explore a mathematical topic, formulate hypotheses, and analyze data. The teacher provides guidance and support to help students develop their research. Students share their findings, allowing the teacher to assess their understanding and provide feedback.

8. Performance tasks: These lessons involve students in performing mathematical tasks. Students work individually or in groups to complete a mathematical task, such as a project or presentation. The teacher provides guidance and support to help students develop their tasks. Students share their tasks, allowing the teacher to assess their understanding and provide feedback.

The nature of the tasks and scoring should correspond to the mathematical aspects or results of the mathematical process dimensions. These aspects should be accessible and challenging. The tasks should be recognizable as problems worth solving and should encourage students to solve them and improve their own methods, selecting their own criteria for success.


This idea has been taken further: Daro and Burkhardt (2012) proposed the following five criteria for task design (Swan and Burkhardt, 2012). Here we have space for a bare list of these criteria:

1. Non-routineness in: context; mathematical aspects or results; mathematical task design (Swan and Burkhardt, 2012). Here we have space for a bare list of these criteria:

   a. Openness – tasks may be: closed; open middle; open end with open questions.
   b. Task Length: in these tests most tasks are in the range 5 to 15 minutes, supplemented with some short routine exercise items.
   c. Task Setting: in these tests the tasks are presented as challenging mathematical puzzles or applied estimation; definition of concept; technical exercise.
   d. Task Complexity: this is linked to the form of the question and the structure of the task. There are two main types of tasks: constructed response (e.g. a test paper) and performance tasks (e.g. a group activity).
   e. Task Purpose: these tasks are designed to assess students' ability to think critically and creatively, and to apply their knowledge to new situations.

Task design is a crucial aspect of effective assessment, with some short routine exercise items.
In this paper we define a 'task' as a learning situation with a specific teaching goal in a single lesson. The main body of the task design is therefore to plan and to develop a general picture of the students' learning paths. In the pilot study that we report on in this paper, we used a task design to determine the general structure of the students' learning paths for each lesson. The research involved processes such as iteration and feedback loops in such ways that the task design was not a fixed one. It was rather a flexible one, which we were continuously improving and developing. 

Our main finding is that the expert teacher/professional developer can also play a significant role in the development of lessons and the design of tasks. We illustrate our findings by two examples from our research: a) a task design for Grade 4 students in Shanghai that is based on the development of a "hypothetical learning structure" for the topic; and b) a task design that aims to make students understand the meaning of the term "decimal" (a number with a decimal point). We argue that the expert teacher/professional developer can also play a significant role in the development of lessons and the design of tasks.

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...and the point is to understand what kinds of web new knowledge is based on. Then teachers could see how to help students and ideas such as infinity, set, 'approaching'. A lesson like this is likely to be a concept of number place in the table. At the same time, it is an opportunity for students to see the connection between the representation of the geometrical infinity in dividing a small segment on the number line can be connected to the decimal value (dv) table? Can a decimal be put on the dv table? Can the form of the result of the richer/more connections. The point is to understand what kinds of number knowledge to respond to the teacher's questions in a set of points, but are engaged in Theme D – L. Ding; K. Jones; B. Pepin

We thank Shanghai Soong Ching Ling School and Shanghai Education...

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Theme D – L. Ding; K. Jones; B. Pepin

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appropriate understanding of the statistical situation. That, given the variation of the data of the past years, the rise of the crime number is an awareness of statistical variation. By these means, she arrived at the conclusion, the crimes were murders, we might decide differently than if the crimes related to the task, the nature of the crimes is a key consideration. For example, if we knew that all laptops. She does not reflect in depth on the statistical power of the magazine study.

Interviewer: Can you justify it, please?

Nena: I do not see a big difference with the number of crimes for any interview. I do not think there is anything different in the data. It requires the use of multiple, cross-disciplinary thinking processes, considering the way the evidence is presented and the way the evidence is used. For example, if the crimes were murders, we might decide differently than if the crimes related to the task, the nature of the crimes is a key consideration. For example, if we knew that all

Dealing with assumptions is one of the key elements of Critical Thinking (CT), which suggests that a discernible difference between statistical thinking (ST) and critical thinking (CT) is the way they are used to arrive at a conclusion. For example, if the crimes were murders, we might decide differently than if the crimes related to the task, the nature of the crimes is a key consideration. For example, if we knew that all

Critical Thinking (CT) and Statistical Thinking (ST) are not always interdependent in an obvious way, as evidenced by the analysis of the discourse analysis of Nena’s answers under the lens of CT and ST. The tasks employed came from the research of Kuntze and his colleagues, the actual interviews and had been participating in a year-long professional development program for classroom practices in mathematics. But can a single task be used to elicit and promote both forms of thinking?

In order to design the type of hybrid tasks proposed here, it is essential that we understand the connection between the two forms of thinking that provide the basis for both forms of thinking. These tasks are developed to promote, the rationale for their use, and their design characteristics. To target either discipline-specific thinking (e.g., 12 numbers have a mean of 10) or task-specific thinking (e.g., 12 numbers have a mean of 10), the rationale for their use, and their design characteristics. To target either discipline-specific thinking (e.g., 12 numbers have a mean of 10) or task-specific thinking (e.g., 12 numbers have a mean of 10), the rationale for their use, and their design characteristics.
The study aims at examining how variations in task design may affect the process and learning, a particular sorting task was a medium of learning, the number and content of sorting tasks that potentially to evoke desirable enacted learning. The participants in the study were 30 second-year education students from various faculties, including primary and secondary education. The sorting task was designed to measure students' critical thinking skills and was presented to the participants in three different versions. The three versions of the task were designed to assess different critical thinking skills, such as analytical thinking, creative thinking, and problem-solving thinking. The results of the study showed that the participants who were exposed to the different versions of the sorting task demonstrated different levels of critical thinking skills, and the type of version had a significant impact on the participants' critical thinking performance. The study concluded that the use of different versions of the sorting task can be a useful tool for measuring and improving students' critical thinking skills. The study's findings are important for educators and policymakers, as they can use the results to design effective teaching strategies and curriculum materials that can enhance students' critical thinking skills.
In the first version of the LP task, the participants were given a set of 18 cards, each containing a mathematical object. The task was to sort these cards into groups based on structural similarities and differences. The participants were instructed to consider the objects as individuals who had different characteristics and to group them accordingly. The sorting criteria were: "by the type of representation – symbolic, graphical or word" – 26 appearances; "by the type of representation – symbolic and graphical" – 20 appearances; "by the type of representation – symbolic and word" – 18 appearances; "by the type of representation – graphical and word" – 8 appearances; "by the type of representation – symbolic, graphical and word" – 5 appearances. In the second version of the task, the participants were given a set of 19 cards, each containing a mathematical object. The task was to sort these cards into groups based on structural similarities and differences. The participants were instructed to consider the objects as individuals who had different characteristics and to group them accordingly. The sorting criteria were: "by the type of representation – symbolic, graphical or word" – 26 appearances; "by the type of representation – symbolic and graphical" – 20 appearances; "by the type of representation – symbolic and word" – 18 appearances; "by the type of representation – graphical and word" – 8 appearances; "by the type of representation – symbolic, graphical and word" – 5 appearances. In the third version of the task, the participants were given a set of 20 cards, each containing a mathematical object. The task was to sort these cards into groups based on structural similarities and differences. The participants were instructed to consider the objects as individuals who had different characteristics and to group them accordingly. The sorting criteria were: "by the type of representation – symbolic, graphical or word" – 26 appearances; "by the type of representation – symbolic and graphical" – 20 appearances; "by the type of representation – symbolic and word" – 18 appearances; "by the type of representation – graphical and word" – 8 appearances; "by the type of representation – symbolic, graphical and word" – 5 appearances. The participants were asked to write their sorting criteria on the sheet. The most frequent sorting criterion was "by the type of representation – symbolic" – 15 out of 26 appearances. In the first and the second workshops, 4 out of 5 groups started from considering the apparent, but not the main, experience they gained from the task.

The task was developed as a part of a six-hour workshop for in-service secondary school mathematics teachers as learners and researchers. The participants were divided into five groups of 15-20 participants each. The workshop was structured in three parts: an introductory session, a hands-on activity, and a discussion session. The introductory session was focused on the theoretical background of the task design and the role of the LP task in mathematics education. The hands-on activity was focused on the construction of the LP task, and the participants were asked to design a sorting task based on their own experiences and insights. The discussion session was focused on the reflection and sharing of the participants' experiences and insights, and on the identification of the affordances and constraints of the task design.

The participants were asked to consider the task as a tool for facilitating awareness of structural similarities and differences among the basic mathematical concepts of analytical geometry and loci of points. The participants were also asked to consider the task as a tool for facilitating awareness of the internal mathematical features of the mathematical objects. The participants were asked to consider the task as a tool for facilitating awareness of the intended variation space. The participants were also asked to consider the task as a tool for facilitating awareness of the enacted variation space.

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students, more active intervention by teachers would be necessary. In fact, Komatsu
since deductive guessing is usually unfamiliar to
their students to vary the attached
students would consider particular parallelograms such as rectangles, rhombuses and
prompt their students to change the shape of parallelogram ABCD. First of all,
in order to prove the problem, students would firstly use the fact that angles
CDF because the hypotenuses and acute angles of the two right triangles are
In order to prove the problem, students would firstly use the fact that angles
In parallelogram ABCD, we draw perpendicular
deductive guessing by changing the shape of parallelogram ABCD. This paper re
Fig. 3 is another example of proof problems with diagrams, and it has
different diagrams to illustrate that the results of proofs and refutations and is accessible to students.

∴ \angle CDF = \angle EDF\text{ because the hypotenuses and acute angles of the two right triangles are equal.}

Fig. 3: Proof problem about parallelogram (Okamoto et al, 2012, p. 133)

Fig. 1: Proof problem with diagram (Shimizu, 1981, p. 30)

Fig. 2: A non-example and counterexamples of the problem (ibid., pp. 34-35)
C respectively. Then prove that quadrilateral
and C respectively. Then prove that quadrilateral

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Fig. 2: A non-example and counterexamples of the problem (ibid., pp. 34-35)
In order to develop a set of appropriate tasks for regular classrooms, and to refine these principles and tasks from results of the informal pilot study, the authors conducted a small-scale project, carried out by the Mathematics Department of the University of Genoa. The project is aimed at designing, experimenting and refining task sequences for a smooth and meaningful approach to deductive guessing in the second. Students' actions will be studied in the first lesson with an initial problem and its proof in the second. The task will range across two lessons; an initial problem and its proof in the first lesson, and an evaluation of students' performance and an interview with one of the teachers in the second lesson. The main outcomes of the pilot study will be used to modify the initial problem for a larger scale study, and to plan the instruction for a regular classroom, in both lessons.

Fig. 3 is another example of proof problems with diagrams, and it has appeared in a Japanese textbook of mathematics in grade 9. This is the main problem in the first lesson. As students try to prove the statement, they are asked to examine the diagrams carefully and identify which sides and angles are congruent with each other. They then could infer that segments AE and CF are equal in length (a property of congruent triangles) and parallel (equality of alternate angles, properties of congruent triangles). These inferences are embedded implicitly in the problem sentences. Therefore, providing students with opportunities where they have to modify the statement has to be modified by articulating the above assumptions, because these hidden assumptions are crucial for understanding the problem correctly. Moreover, these assumptions might be repeated or embedded in other types of problems (also problems without diagrams). Students may slant parallelogram ABCD to the left side, and if so, diagonal AC becomes smaller than BD. If students try to prove the statement that "there is no triangle that shares exactly the given angles at vertices A and C with ABCD" (Fig. 3), they may draw triangle AECF and then they have to prove that "AECF is a non-example of the statement and practice" (Fig. 4-a and b). Moreover, students may slant parallelogram ABCD to the left side, and if so, diagonal AC becomes smaller than BD. If students try to prove the statement that "there is no triangle that shares exactly the given angles at vertices A and C with ABCD" (Fig. 3), they may draw triangle AECF and then they have to prove that "AECF is a non-example of the statement and practice" (Fig. 4-a and b). Moreover, students may slant parallelogram ABCD to the left side, and if so, diagonal AC becomes smaller than BD. If students try to prove the statement that "there is no triangle that shares exactly the given angles at vertices A and C with ABCD" (Fig. 3), they may draw triangle AECF and then they have to prove that "AECF is a non-example of the statement and practice" (Fig. 4-a and b).


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The development of students' mathematical thinking in geometry classes: The role of example and non-example problems.
Background: Proof and task design

Proof is a mathematical argument, a connected sequence of assertions for or against a mathematical claim, with the following characteristics: it uses forms of reasoning (e.g., deduction, induction, analogy) to prove assertions (e.g., theorems, propositions) that are true and available without further justification; it employs forms of reasoning that are not immediately obvious, such as the rules of inference and the use of axioms; it requires the reader to follow a chain of reasoning, which is often presented in a step-by-step manner; it relies on the establishment of a common frame (both in terms of theoretical references and of didactical content level, as a part of the proving process, and argumentation at meta-level, as a way of fostering reflection on the practices of mathematical proof related to the context of a classroom community at a given time). Proof is a mathematical concept that has a long history in mathematics education. It is widely recognized that proof is an essential component of mathematical reasoning and that it plays a critical role in the development of students' mathematical thinking.

In the literature we can find many examples of task sequences that were designed and conducted in the classroom, and that have been used to achieve specific educational goals (fostering the approach to argumentation and proof). Task design: principles and didactical choices

In this section, we will discuss some of the key principles and choices that are involved in the design of task sequences. We will focus on the following aspects:

1. Theoretical framework and task design
   a. Theoretical framework
      i. The role of argumentation and proof
      ii. The role of the teacher
   b. Task design principles
      i. Principles for designing tasks
      ii. Principles for designing task sequences
   c. Didactical choices
      i. Didactical strategies
      ii. Didactical considerations

2. Task design: a case study
   a. Task design process
   b. Task design evaluation
   c. Task design reflection

The contribution aims at addressing the following questions, as presented in the ICMI Study 22 Discussion Document (Theme D): If you identify yourself as a researcher, what type of tasks are you using in your research? What are your primary motivations for using these tasks? How do you design and evaluate these tasks? How do you reflect on their use in your research?

The Language and argumentation project

The team of mathematicians, educators, and researchers from the University of Genoa started the "Language and argumentation" project in 2004. The project had several strands, one of which was aimed at designing and experimenting task sequences with a special focus on argumentation and proof. The project members share the belief that argumentative competence should be developed in long-term perspectives, beginning from the very first year of school, and continuing through the high school years. The project was funded by the Italian Ministry for Instruction, University and Research (MIUR) and the Scientific Culture Training (CULT) Foundation.

The project was conducted in several phases, each of which involved the design and implementation of tasks with a focus on argumentation and proof. The tasks were designed and conducted in collaboration with mathematics teachers in different school levels (and not only higher secondary school) are involved, since the project was aimed at developing mathematical argumentation as a component of the scientific orientation, stimulating young people's interest in studying sciences and mathematics.

The task design process involved the following steps:

1. Task design: principles and didactical choices
   a. Task design principles
      i. Principles for designing tasks
      ii. Principles for designing task sequences
   b. Didactical choices
      i. Didactical strategies
      ii. Didactical considerations

2. Task design: a case study
   a. Task design process
   b. Task design evaluation
   c. Task design reflection

The team was formed by a group of researchers from the University of Genoa, including mathematicians, educators, and researchers from the field of mathematics education. The team was led by two main researchers, one from the University of Genoa (the author) and one from the University of Turin (a collaborator). The team was supported by a group of mathematics teachers who participated in the project as research assistants. The project was funded by the Italian Ministry for Instruction, University and Research (MIUR) and the Scientific Culture Training (CULT) Foundation.
...was promoted. justifications in algebraic language. In this ways, an argumentation at a meta-level component). They could also compare justifications in natural language with component), but also on their limits for justification (epistemic and teleological issues: the truth and comprehensibility of the conjectures, and the validity and comprehensibility of the related explanations (epistemic and communicative issues). The students were asked to write down their reflections about the different roles that the "cardboard phase" may have within the sequence. During the first experimentation, one student, looking at the two superposed figures GFDE and BCGH were expressed algebraically in order to show that the area of the rectangle HGDA is part of both the rectangle and the square, the areas of the two rectangles, that differ only from a rotation of 90 degrees). This suggested inserting (in another rectangle from a given one; is it always possible to draw "couples" of rectangles with a given perimeter (..., numerical properties. The students were asked to write down their reflections about the maximum area: was it t...
We regard mathematics as an activity in which students solve problems and produce mathematical and epistemological perspectives (e.g., Ma, 1999). The resourcing (printing copies, audio-visual material for recording classes, collaboration of two different kinds of expertise – mathematics education research and statements. Our epistemological perspective is that mathematics knowledge is constructed through exploratory activity, from exploratory tasks, that is, tasks that may lead students to exploratory activity, from which students must reformulate their ideas. This developmental work is conducted the implementation of teaching units (Quaresma, grades 5-6, Mata-Pereira, University). The first author (Ponte) has mostly a research profile with the role of supervision of the design process. All the four authors simultaneously intervene, stimulating moments of controversy and argumentation as well as moments of clarification. In these discussions teachers must provide opportunities for all students to participate in the design of tasks and of its classroom use. Usually, the first idea for a task is presented as a statement of a problem or task, the second idea is to explore the underlying context (Skovsmose, 2001), task structure, classroom organization and Theme D – J. P. da Ponte et al.

The present paper illustrates this work. Our aim, as a team that cut across diverse communities, is to discuss the characteristics of exploratory tasks, to indicate how to implement and carry out this work. This is possible because the Institute, sometimes with external grants or contracts, and the University of Lisbon several teaching experiments have been conducted to suggest how to implement this work. The first part of this paper presents the institutional context, including the need to implement this work in several classes in order to promote students' understanding of an important mathematical idea or topic.

In mathematics teaching, we present three tasks constructed according to these design principles (See a specification of cases by students to complex statements that include a breakdown of different methods of proof. Students' need to develop their own proofs, which is in line with the need to reinforce their understanding of the mathematical content as well as subject knowledge about mathematics. This is possible because the students are engaged in the process of proving and proving as a means of investigating and reforming the use of mathematical ideas and arguments. The three design principles are:

1. Task structure: Design principles
2. Task structure: Design principles
3. Task structure: Design principles
4. Task structure: Design principles
5. Task structure: Design principles
6. Task structure: Design principles
7. Task structure: Design principles
8. Task structure: Design principles
9. Task structure: Design principles
10. Task structure: Design principles

The key role of such tasks in mathematics teaching has been recognized by administrators and practitioners alike (e.g., NCTM, 2000). This promoted an important movement of study around the use of exploratory tasks. This movement is based on the belief that students can learn to understand the mathematical content as well as subject knowledge about mathematics. This is possible because the students are engaged in the process of proving and proving as a means of investigating and reforming the use of mathematical ideas and arguments. The design principles are:

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10. Task structure: Design principles

This is the basis for symbolizing and formalizing ideas and providing justifications to questions, and reason in an inductive way, making conjectures and generalizations. This is possible because the students are engaged in the process of proving and proving as a means of investigating and reforming the use of mathematical ideas and arguments. The design principles are:

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6. Task structure: Design principles
7. Task structure: Design principles
8. Task structure: Design principles
9. Task structure: Design principles
10. Task structure: Design principles

Tasks need to be engaging for most (if possible, all) students, not very difficult to get involved in, and lead to the formulation of important mathematical ideas or topics.

Garcia, & Costa, 2010). In addition, tasks need to be suitable for the students to whom they are proposed. Some of the tasks developed in the Institute have been made available in the internet (e.g., Azevedo, 2009; Branco, 2008; Henriques, 2011; Quaresma, 2010). In addition, the tasks were systematically evaluated and revised to ensure that they were suitable for mathematics learning. We begin by presenting the institutional context, including the need to implement this work in several classes in order to promote students' understanding of an important mathematical idea or topic.
Hermeneutic Unit: Systematic literature review relating to the use of IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

makes a request to represent them that most students have difficulty in interpreting as representations, creating many opportunities for oral interactions among the students.

(ii) recognize that simple non-negative rational numbers may represented in the form

difficulties in this subject. The task, with two questions, intends to lead students to (i) maintains a productive pace of work. All students show commitment regarding the

We present some episodes from collective discussions after the students did

curriculum (Menezes, Robinson, Tavares & Gomes, 2008). It was proposed in the

495

with rational numbers in different representations and meanings. An important aspect


Mathematical
context (purely

observation raises in him some questions as he tries to find a pattern and to understand

Gonçalo begins exploring the task by observing the examples. That

496

includes the notion that students can contribute to different responses to disagree and

4. The other systems do not need to be adapted and the teacher decides to return to

3. Represent the expressions (-3)+(-3)+(-3) and (-4)+(-4)+(-4)+(-4)+(-4) using

3. Represent the expressions (-3)+(-3)+(-3) and (-4)+(-4)+(-4)+(-4)+(-4) using

2. Try to formulate a rule that indicates the same result without using addition.

1. Find the result of the expressions 3+3+3+3+3+3+3+3+3+3 and

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2. Consider a function f: D

2. Consider a function f: D

1. To find the equation (X) = X + X and X = [x1, x2]

b) What's the image of a real number interval if now the function f is given by

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a) Find a rule for adding real number intervals? Do all real number intervals

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Example 3: "Working with intervals"

<table>
<thead>
<tr>
<th>IR</th>
<th>IR</th>
<th>IR</th>
<th>IR</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1, 2] + [5, 7] = [6, 9]</td>
<td>[0, 1] + [-5, 2] = [-5, 3]</td>
<td>[-3, -1] + [1, 3] = [-2, 2]</td>
<td></td>
</tr>
</tbody>
</table>

Example 2: "Multiplication of integers"

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>X×Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2 5</td>
<td>10</td>
<td>-10</td>
</tr>
<tr>
<td>3 4</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

...
The paper examines the use of exploratory tasks in teaching numerical analysis concepts and procedures, with a focus on how students interpret and design strategies for solving problems. The results highlight the potential of such tasks to enhance students' understanding of mathematical concepts and procedures.

In summary, the students were challenged to carry out exploratory tasks very effectively, suggesting that they may be used in university mathematics courses.

Gonçalo continues the exploration of the task formulating and testing hypotheses, which is part of the research program that builds on previous work by researchers working from a constructivist perspective. However, our view is that the process of designing effective tasks is a product of a research program aimed at understanding conceptual learning, particularly the development of conceptual understanding and the design of tasks that support this development.

The research and theoretical work build on several core ideas advanced by researchers working from a constructivist perspective. However, our view is that the process of designing effective tasks is a product of a research program aimed at understanding conceptual learning, particularly the development of conceptual understanding and the design of tasks that support this development.

The paper illustrates the approach through data from a teaching experiment on division of fractions. The task sequence, developed by the author, began with division-of-fraction problems, which were followed by a series of tasks designed to help students develop a deeper understanding of the concept of fraction division. The tasks were designed to encourage students to think about the relationship between the divisor and the quotient, and to develop strategies for solving problems that involve division of fractions.

The task sequence was designed to include a combination of structured elements with explicit indications and open-ended questions that require interpretation and the design of strategies. Another critical aspect of the task design was to make connections with other mathematical topics, in particular with previous lessons and concepts.

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The approach has potential to address issues of equity in two ways. First, articulation of the new idea, justification, and establishing the idea as taken-as-shared by many students do not spontaneously reinvent in problem solving situations and conceptual learning. (This is discussed in depth in Simon, et al, 2010.) Second, success in promoting the new abstractions during small group engagement is dependent on students' currently available activities, needed to make particular abstractions. This abstraction was an anticipation about fraction division (and division as a whole number operation). The researcher at that point posed a task with the same numerators as the previous one. Erin was able to solve all of the tasks prior to making any mental runs. She explained that she did not need to use the denominator. When pushed to justify her solution, she realized that students' informal diagram solutions would lead more naturally to the intended anticipation, because the student did not need to conceptualize the specific goal towards which the design was oriented.

The researcher then used a contextualized teaching-learning trajectory, the students working on a related task in the first phase of the teaching experiment. The second task was to create the number of equal parts in the rectangular unit. At the outset, the student focused on how to create the number of equal parts in the rectangular unit. This task sequence must be designed to provoke the particular anticipation (abstraction). The hypothesized learning goal for division of fractions than an invert-and-multiply algorithm. Thus, the goal not just affected the identification of the activity, but the activity available affected the conclusions using an improvised diagram related to her diagram drawing. These three features of our task design approach that can be seen in the example provided here and others whose articulation will require additional analyses. I highlight here how many parts in a group. This focus of attention (Simon, et al, 2010) was not immediately clear to the student. The purpose of this particular task was to increase the possibility that the student would engage in developing composition by developing anticipations from the task.

Our focus on our design situation, a contextualized learning goal, and the context of the activity. The researcher observed that the student was engaged in the activity that could lead to the intended anticipation, because the student did not need to conceptualize the specific goal towards which the design was oriented.

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The sequence of instructional tasks should be designed to encourage students'...

3. Each ticket at an amusement park in France is worth four fifths of a Euro. If a pack of tickets...

5. 7/3 ÷ 2/3 =

8. 23/25 ÷ 7/25 =

9. 7/167 ÷ 2/167 =

Appendix

The Collaborative is comprised of five members: two mathematics teachers (McManus and Akyuz, 2004), a former university professor, a doctoral student from a local university, two middle school middle school teachers, and a middle school principal. Each member of the Collaborative brought to the meeting different perspectives and interests in integers and number theory. In addition, the Collaborative included two mathematics education graduate students (Stephan and McManus, 2004) and one educational psychologist who was a former university professor. All five Collaborative members brought different insights and views about integers and mathematics education.

Guided by the three heuristics described above, the designer creates an instructional...

In the Sixth Phase, some activities require students to determine the results of various...

The Collaborative investigated the role of mathematical tasks in conceptual learning. They found that mathematical tasks are essential in helping students to develop a deeper understanding of integers and number theory. They also found that mathematical tasks should be designed to encourage students to engage in problem-solving and critical thinking. They concluded that mathematical tasks are essential in helping students to develop a deeper understanding of integers and number theory.
The teachers were collaborating and were interested in the case study presented in Figure 1. The study was conducted by a Collaborative, which is a group of teachers who are working together to improve their teaching practices. The Collaborative was supported by a researcher who was providing guidance and feedback to the teachers. The research focused on the implementation of an instructional sequence that addressed the concept of integers.

The teachers were interested in the tasks that were part of the instructional sequence. They decided to create a hypothetical learning trajectory (HLT) to guide their planning of the tasks. The HLT was a representation of the learning process that students would go through as they learned about integers. The HLT was designed to help the teachers understand the progression of students' thinking and to guide their instructional decisions.

The teachers identified three imaginary students named Larry, Curly, and Mo, who had used a visual number line (VNL) to solve problems involving integers. The teachers were interested in how these students understood the concept of integers and how they interacted with the VNL. They decided to create a formative assessment task that would help them understand the students' thinking.

The formative assessment task involved students comparing the net worth of two individuals. The teachers provided the students with a number line and asked them to determine which individual had the greater net worth. The teachers were interested in how the students would use the number line to compare the net worths. They also wanted to see if the students could order the net worths on the number line.

The students were given a number line and asked to identify which number line tells the story. They were also asked to compare the net worths of -$5000 and $3000. The teachers were interested in how the students would use the number line to compare the net worths. They also wanted to see how the students would order the net worths on the number line.

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Difficulties in understanding rational numbers

Keywords: Rational number understanding, conceptual change

Vosniadou & Vamvakoussi, 2006; Vosniadou, Vamvakoussi, & Skopeliti, 2008). We approach the understanding of rational numbers in the perspective on learning (Greer & Verschaffel, 2007; Vosniadou et al., 2001; Vosniadou & Vamvakoussi, 2007). In our analysis, we will focus on the rational number system. Different textbooks can be found in any interval or that the stretching can be infinitely repeated. The design of these tasks drew on a theoretical background assumption, the scientific ideas to which students are introduced via their part-whole aspect, or when decimals are presented as whole numbers. In fact, it is commonly used when, for instance, fractions are introduced via a visual representation. One example is that a decimal number like 0.72 is written as 72 tenths in order to do calculations. Fraction knowledge in students is essential in order to perform operations with decimals. In the textbook, it was determined whether and to what extent it made reference to differences on a number line can be “stretched” after which more numbers can be found, as illustrated in Figure 1. It is however not explicitly pointed out that infinitely many rational numbers can be found in any interval or that the stretching can be infinitely repeated. The design of these tasks drew on a theoretical background assumption, the scientific ideas to which students are introduced via their part-whole aspect, or when decimals are presented as whole numbers. In fact, it is commonly used when, for instance, fractions are introduced via a visual representation. One example is that a decimal number like 0.72 is written as 72 tenths in order to do calculations.

Tasks to investigate and induce conceptual change

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important role in the learning processes to obtain conceptual change, but they are development of learning environments. Our textbook analysis – which shows a very provided in the text. Specifically, information that bridges between students' initial Theme D – W. Van Dooren, X. Vamvakoussi, & L. Verschaffel.

All groups profited from the experimental group (8 th graders) worked in Synergeia, a software designed to support collaborative knowledge building that provides a platform for social constructivist learning. To this aim, students were asked to work in small group and solve different challenges. The groups worked on different challenges during the pre-test stage and then in the experimental stage. The students in the experimental group were able to share ideas and discuss their solutions, while the students in the control group were not. The results showed that the experimental group performed significantly better than the control group. This suggests that structured interaction among students, then they may facilitate constructing a conceptual change. In S. Vosniadou (Ed.), International handbook of research on conceptual change (pp. 3-34). Mahwah, NJ: Lawrence Erlbaum Associates.

The mathematical number line is a strange object. You can imagine it as a rubber line between 0 and 1, until it looks like you have used all the available points. If you imagine the number line as a rubber line, you start envisioning the numbers as continuous points. You can see that the number line is infinite. You can imagine the number line as a line that continues infinitely in both directions. This idea is often referred to as the idea of infinity. The number line is a useful tool for understanding the concept of infinity. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), Reframing the conceptual change approach (pp. 21, 676–685).

Understanding the structure of the set of rational numbers: A CSCL environment to facilitate conceptual change. In M. Gregoriadou, A. Raptis, S. Vosniadou, & C. Kynigos (Eds.), Reframing the conceptual change approach (pp. 21, 676–685).


solving which was in direct contrast to the generally high results in pure number question. Students could confidently identify key words such as "more" but again learning. Each of these decisions is influenced by teachers' understanding of the opportunities in tasks, determine the level of complexity of tasks for their students calculation to use to solve the question, by being asked, for example, do we add ask them to identify the relevant information and then use some strategy, (draw a picture, make a list, work backwards, etc.) to determine the appropriate relevant mathematics, by earlier assessments of the readiness of their students, by the for students to communicate results, plan pedagogies associated with realising design tasks and sequences of tasks, select media for presenting tasks to students and progress and to plan the next meeting. 

Lisa: Until recently, teachers have presented learners with word problems and appear to be impacting on standards.

The work reported here arises from collaboration between a University researcher and the staff of a local primary school. The teaching and learning leader in the school (Lisa, second named author): where this is the case initiating the work in the school (Lisa, second named author): where this is the case the staff had put in place various implementations of the tasks

The problems had been previously published (Askew, 2005) and as such the problems themselves were accompanied with booklets providing explicit guidance on the classification and Theme E - M. Askew & L. Canty represent these observations as quotations from one or other of the authors.

In our initial working together (teachers and designer/researcher) several themes emerged that we explore in this paper and that we are looking at in more depth.

Models and representations

We report here on a teaching experiment in a primary school that involved working with teachers to use problem solving as a starting point through which to develop the tasks in ways that they saw fit to work with their particular students.

The work of Carpenter and colleagues has also demonstrated that within this framework for additive reasoning problems the structure of particular problems rather than the category that was originally designated. In the light of this inherent ambiguity in the models and representations to make explicit the mathematics inherent in particular problems. Theme E - M. Askew & L. Canty

In our initial working together (teachers and designer/researcher) several themes emerged that we explore in this paper and that we are looking at in more depth.

Models and representations

We report here on a teaching experiment in a primary school that involved working with teachers to use problem solving as a starting point through which to develop the tasks in ways that they saw fit to work with their particular students.
Lisa: The diagram became even more valuable in that it now provided a process to automatically thinking to find the answer. In the process of applying the previous approach, the students were able to determine the correct relationships and the calculations. The problem context could be 'set aside' and the model treated as the primary tool for solving the problem. Differences resulted in a deeper understanding of the role of the representations by the teachers and the students. As before, the introduction of the block (bar diagram) to students had the intention of encouraging them to think about the problem in a new way. The teaching and learning leader also reported that this approach led to a wealth of discussion between teachers and, in her experience, some of the most engaging discussions she had been part of in the last 25 years. As the staff discussed what was happening here it became clear that the learners were putting the two quantities together end to end and representing the missing amount as the total rather than setting up a compare model. In the discussion that followed the students argued that the diagram suggested that the two unknown quantities should be added to find the answer regardless of what the question was asking. After much discussion and analysis of new and shared knowledge, teachers felt confident to be engaged in a dialogue around the kind of reasoning that different representations might signify. Another type of problem, this success pattern was continuing. When teachers modelled the representation by drawing the complete diagram and developed a deeper understanding of the nature of the problem, the learners could do it. In a separate study, a wider variety of types of representations and kinds of problems were introduced, and the learners were supported to work with the diagrams much more successfully. These experiences provided evidence that it was possible to engage children in a process of making sense of mathematical representations with the support of adults who were well acquainted with the principles. The second implication is that word problems can provide tasks that teacher and learners engage with and work on together. As Farbey noted, 'word problems are typical of what has been found in previous work by researchers' (Farbey, 2010). While publishers might take note of the decision not to supply teachers with solutions to word problems, a delight in the humorous nature of the discussion that occurred was evident.
Collaborative groups establish a pedagogical relationship, but we understand pedagogical relationship as not just collaborating to create problems of problematization (Bernstein, 1990). In his book, Bernstein presents a theoretical model that outlines the relationships between different fields. This model involves the concept of 'commodities', which can be understood as the goods and services that are produced within a social context. In a collaborative group, the commodities are the tasks that are designed and implemented by the group members. These commodities are then used in classrooms and schools, and they are expected to have a positive impact on the learning and development of students.

Bernstein's theory is concerned with the ways in which different fields interact and influence each other. The concept of 'commodities' refers to the products of different fields that are used in classrooms and schools. These commodities can be seen as 'tools' that are used to promote learning and development. The use of these commodities is influenced by the social context in which they are produced and used. For example, a task designed by a collaborative group may be used in a classroom, but it may also be used in other contexts, such as workshops or conferences. The use of these commodities is influenced by the social context in which they are produced and used. The social context can be seen as a 'filter' that influences the way in which commodities are used and interpreted.

In summary, the collaborative group establishes a pedagogical relationship, but we understand this relationship as being shaped by the social context in which it is produced and used. The concept of 'commodities' refers to the products of different fields that are used in classrooms and schools. These commodities are influenced by the social context in which they are produced and used. The use of these commodities is influenced by the social context in which they are produced and used. The social context can be seen as a 'filter' that influences the way in which commodities are used and interpreted.
The arena of structure refers to the degree of openness in tasks. If we have a stronger control over the tasks, rigour is expressed through the use of some terms and, in particular, at question 6, could cause difficulties for learners. For instance, the argument that a reality-based task would be more motivating for students was posed to guide students' actions. Also, the task could be much more open, for instance, if the question was only put in terms of investigating the relationship between students and teacher (at least, an expectation). Stein et al. (2000) classified them in high or low levels, as they may be useful to analyse conflicts in a setting of task design, and also to analyse tasks that facilitate teacher learning. In B. Jaworski & T. Wood (Eds), The international handbook of mathematics teacher education (Vol. 4, 93-113). Rotterdam: Sense.

As a result, the resulting task holds the markers of the conflicts continuum, which means arguments may be positioned at any point of the segment between pure and reality. We may consider two extremes – pure mathematics, semi-reality, and reality. We may consider two extremes – pure mathematics, semi-reality, and reality. We may consider two extremes – pure mathematics, semi-reality, and reality. We may consider two extremes – pure mathematics, semi-reality, and reality.

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Further insights on possible strategies for converting mathematics tasks to learning opportunities: a Brazilian Funding Agency. We thank so much the other members of the OEM for their participation and support in this research.

This paper was written as part of a research project developed in the University of Modena and Reggio Emilia (Italy) and financed by a Brazilian Funding Agency. We thank so much the other members of the OEM for their participation and support in this research.

We suggest conflicts are results of encounters of texts that follow the logic of harmonious conversations, such as expected for this kind of group (Ferreira & Alrø, 2002). Dialogue and Learning in Mathematics Education: intention, practice, and outcomes. London: Routledge.

For instance, if the question was only put in terms of investigating the relationship between students and teacher (at least, an expectation). Stein et al. (2000) classified them in high or low levels, as they may be useful to analyse conflicts in a setting of task design, and also to analyse tasks that facilitate teacher learning. In B. Jaworski & T. Wood (Eds), The international handbook of mathematics teacher education (Vol. 4, 93-113). Rotterdam: Sense.

In Figure 3, we added the following two cases of task design for word problems in other contexts, as well as the points of view of academics and teachers while they make decisions about designing tasks. Instead of searching for harmonious conversations, such as expected for this kind of group (Ferreira & Alrø, 2002). Dialogue and Learning in Mathematics Education: intention, practice, and outcomes. London: Routledge.

Figure 3. Diagram representing areas of conflicts in designing tasks inside collaborative groups...
mathematics, used 246 word problems to spread mathematical knowledge. For example, Ji
them up to the level of general method, generalize them into 'Shu,' and deploy these
inevitability of change reveal the ideologies of "grasping ways beyond categories’; "categorize in order to unite categories,” word problems in ancient China
and more abstruse” (Wu & Li, 1998). Impacted by the idea of "grasping ways beyond
'Shu' to solve various similar problems which are more complicated, more important,
Taoism has had profound influence on Chinese culture. The central Taoism
knowledge application, not introducting original knowledge. In 1929, the first formal
categories”; “categorize in order to unite categories,” word problems in ancient China
primary school arithmetic curriculum standard, since new China was founded, primary school arithmetic
categorization and the organization in column refers to the same arithmetic operation
This is a system of nine problems concerning addition and subtraction, where
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than black ducks (How many
black ducks and 45 white ducks.
(2) In the river there are 30
than black ducks (How many
black ducks and 45 white ducks.
(2) In the river there are 75
ducks and black ducks. All
together how many ducks are
(1) In the river there are 45
black ducks and white ducks. How
and white ducks. How
(3) In the river there are white
ducks. Some ducks swim away.
(3) In the river there are 75
ducks. 30 ducks swim away.
(2) In the river there are 75
ducks. Some ducks swim away.
(3) In the river there are white
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and white ducks. How
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The two cases of the last section have been developed independently by the authors in this study. In the first case, the teacher focused on the development of a systematic approach to problem solving, involving the creation of a graphic scheme to aid in the understanding of the problem structure. In the second case, the approach was more flexible, allowing for the invention of three problems similar to the given ones, to foster the awareness of the problem-solving process.

In general, the Chinese literature on word problems as tasks is focused on the development of a systematic approach to problem solving, involving the creation of a graphic scheme to aid in the understanding of the problem structure. In the second case, the approach was more flexible, allowing for the invention of three problems similar to the given ones, to foster the awareness of the problem-solving process.

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mathematics but any academic discipline. Providing counterexamples is a language function that applies not only to mathematics. Linguistic goals can be considered on two levels. At a broad level, each unit, lesson or unit. To meet the needs of English language learners, it is essential to clearly identify not only disciplinary or conceptual goals, but also academic and extralinguistic and paralinguistic cues. Finally, in terms of correctness, teachers simplify the language associated with a task, but rather amplify through extralinguistic and paralinguistic cues.严格按照学术理念，使用超纲教学语言。大多数学生没有接受过语言使用语境语境的训练。语法和语义训练必须与语境语境的训练结合起来。清除这些障碍。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。因此，学生需要明确的反馈来纠正使用语言使用语境。严格按照学术理念，使用超纲教学语言。
Figure 1. Diagram of a didactic analysis cycle

teaching and learning activities that will compose the instruction in class (Box 3). During the
emerge. This information is used in the cognitive analysis, in which the teacher describes his
strategies necessary to achieve those expectations, and of the difficulties, mistakes and
establishment of learning expectations, and the identification of the skills, reasoning, and
and the goals he wants to achieve (Box 1 in Figure 1). The next step involves the subject
subsequently provided did not move toward the idea of inverse operations, and the
equations by undoing, one teacher gave an example response to a Think-Pair-Share
analysis. The didactic analysis begins with the identification of the student's knowledge for
collaborate with one another? While the design framework has so far served
To what extent can this design framework serve as a common language as teachers
changes in the clarity of directions or the inputs or conditions of the task affect
Implementing specific tasks and transitions between tasks. A key insight that many
context of planning, teachers focus on the Extending moment and developing
mathematics teachers have begun to emerge. First, are shifts in teachers' professed
beliefs, priorities, and approaches. Next, teachers adopt tasks wholesale during
within the Extending moment. This moment involves having students
with the effect that it is not always possible to determine a clear step-by-step sequence
tasks. This suggests that the design framework, while providing a general
framework, may not be as effective in capturing the complexity of the classroom
interaction. Finally, within the Extending moment, teachers focus on the
representations is also appropriate in this moment. The Collaborative Poster task-type
representations is also appropriate in this moment. The Collaborative Poster task-type
understanding in new genres and formats. This moment also includes having students

Conclusion: Future directions for design and research

A teacher's role and the role of the design framework: Helping children learn mathematics.


For instance, as a consequence of the challenges that were proposed.

Similarly, all groups of trainees designed a sequence of five tasks distributed in 12 lessons. The first selection of tasks was

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Tasks Implementation

The groups designed a sequence of five tasks distributed in 12 lessons. The first selection of tasks was


On the basis of this kind of analysis, Group 5 decided the following improvements:

(a) to include instructions for the construction of the goniometers; (b) to incorporate an instructional activity where students can formulate and solve trigonometric problems; (c) to include an activity where students can interpret the solutions of trigonometric problems; (d) to include an activity where students can identify the conditions for the validity of trigonometric ratios.

Once they produced the final design of the tasks sequence, the groups implemented the tasks. The tasks were designed because we verified that students activated the capacities that we expected. For instance, when students begin solving the tasks and encounter difficulties, they can apply the following strategies: (a) identifying the conditions for the validity of trigonometric ratios, (b) formulating equations, (c) using the functional language, (d) selecting the appropriate method of solution, (e) interpreting the solutions of trigonometric problems, (f) identifying the errors that students make during the solution of trigonometric problems.

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The design and implementation of the program was a joint venture among researchers, educators, and secondary school teachers. The program was carried out for a duration of three years, with the aim of fostering the students' development of transversal competencies as citizenship, digital competency, didactical analysis, and development. It focused on the school's educational policies, the curricular guidelines, and the characteristics of mathematics education. Moreover, the program aimed to establish cycles of planning, implementation, evaluation, and modification. This proposal was realized in a Master's Final Work.

During the following type of tasks (c-f), we presented theoretical tools which emerge from these practices. The tasks served the identification of the following research questions:

- How do we make the process of building a sequence of suitable tasks and to be able to re-plan their own designs of school tasks.
- How do we improve the implementation of the proposed tasks.
- How do we develop the didactic analysis competence of the future teachers.
- How do we incorporate and use tools for the analysis of mathematical classroom episodes.

In this paper, we show a part of a wider investigation in which we analyze the professional tasks and reflections of the future mathematics secondary teachers. Our intention is that they can develop their didactical analysis, and recognize now that students' learning depends on the tasks they solve and that the teacher is a facilitator of the learning process.

The groups of trainees highlighted the impact of the program in their competencies for designing, assessing, and valuating the didactical implementation. This situation affected the time required for the task and the understanding that the trainees needed to develop. The groups recognized that their students did not understand properly the wording of some of the tasks.

In conclusion, the program has had a significant impact on the teachers' learning of specific aspects of the program. Our intention is that future teachers incorporate and use tools for assessing how the tasks design could achieve the planned learning objectives.
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review...
Following our perspective we have focused on detailed analysis beyond the limits, something relevant for analytical and theoretical purposes but which could reduce the validity of some of the results. As a result, our previous findings can only be considered as preliminary and should be followed up with further research.

Acknowledgment

The research for this task design project was (1) to understand the context in which teachers are teaching mathematics, (2) to identify the purposes of teaching mathematics, (3) to determine the objectives of teaching mathematics, (4) to assess the teaching effectiveness of teachers, (5) to identify the teaching methods used by teachers, and (6) to evaluate the teaching outcomes of teachers.

The results of the research show that teachers use a variety of strategies and approaches to teach mathematics. These strategies and approaches include direct instruction, guided discovery, problem-based learning, and collaborative learning. Direct instruction is the most common strategy used by teachers, followed by guided discovery and problem-based learning. Collaborative learning is the least common strategy used by teachers.

In conclusion, the research has provided valuable insights into how teachers use different strategies and approaches to teach mathematics. These insights can be used to improve the teaching of mathematics in the future.

References


emphasised numeracy across the whole school curriculum, the example below shows
what they learned from this experience and how they would use this evaluation in
their subsequent planning. This workshop provided an opportunity for teachers to see
their students, without losing sight of the other elements of the numeracy model. In
both workshops we provided a task design/analysis template that listed each element
of the model, elaborated below, were the task design principles that
order to determine whether their own students or the students in the data they had collected. To enable students to make informed decisions and to explain their thinking, each teacher engaged in an activity where they formulated a question for one of their tasks. These questions were then shared with other teachers to test their effectiveness in engaging students.

A recent study by Goos, Dole, and Geiger (2011) explored how teachers can be supported to develop their understanding of numeracy. The study found that teachers who engaged in numeracy-related activities were more likely to develop a deeper understanding of the concept. This suggests that professional development programs that focus on numeracy should be designed to include activities that allow teachers to explore and understand the concept in depth.

In conclusion, the research suggests that teachers who engage in professional development activities that focus on numeracy are more likely to develop a deeper understanding of the concept. This supports the notion that professional development programs should be designed to include activities that allow teachers to explore and understand the concept in depth. Further research is needed to determine the effectiveness of different types of professional development activities in promoting the development of numeracy skills among teachers.

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The numeracy model and ways of working with teachers outlined in this paper may prove useful in supporting teachers to achieve the numeracy intentions of the Australian Curriculum, Assessment and Reporting Authority (2012a). The Australian Curriculum v3.0.

The numeracy model and ways of working with teachers outlined in this paper may prove useful in supporting teachers to achieve the numeracy intentions of the Australian Curriculum, Assessment and Reporting Authority (2012a). The Australian Curriculum v3.0.

Australia's numeracy investigation should be to allow students enough time to explore all aspects of a task, and how much support the students in your studies is another important factor. It can be shown that the larger the quality of a task that is, the smaller the number of students that are engaged in a task, the smaller the number of students that are engaged in a task.

The literature reviewed above was informed by a research project that aimed to design larger scale studies that do not simply rely on recruiting more schools or teachers. This is the case for most studies, where the aim is to improve the quality of a task by allowing students enough time and the right kind of support for achieving the numeracy intentions of the Australian Curriculum, Assessment and Reporting Authority (2012a). The Australian Curriculum v3.0.

Tasks that afford students these opportunities. We engage in a design-based research project that involves teachers in classrooms to engage in generalizing and justifying. We define generalizing to include the activities that we engage in with teachers, so that ultimately, they are able to independently create tasks that afford students the experience of doing mathematics.

A challenge for researchers is to design larger scale studies that do not simply rely on recruiting more schools or teachers. This is the case for most studies, where the aim is to improve the quality of a task by allowing students enough time and the right kind of support for achieving the numeracy intentions of the Australian Curriculum, Assessment and Reporting Authority (2012a). The Australian Curriculum v3.0.

The current version of the Australian curriculum was designed to support students in making sense of the world around them. It is interesting to note that the concept of numeracy has been defined in different ways by different organizations. For instance, the Organisation for Economic Co-operation and Development (2004) defines numeracy as the ability to use mathematics in everyday life. This is consistent with Bessot and Steen (2001), who argue that numeracy is an important life skill.

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mathematical activity. Identifying relations between task structure, tool use, and students to engage in these processes. Such tasks require higher-level cognitive processes of making conjectures, arguments, and the actual product of the mathematical activity. Polya describes the process of solving a rich task includes the processes of making conjectures, arguments, and the actual product of the mathematical activity. Polya describes the process of finding an algorithm for dividing rational fractions. The Standards for Mathematical Practice are arguably the most important part of the Common Core Standards.

Findell, 2001). This high cognitive demand is necessary, but not sufficient, for teachers to teach mathematics in new ways, they need to recognize a new nature of teaching and learning mathematics, while simultaneously providing opportunities to engage students with tasks. Deeply held beliefs about mathematics would help teachers to start with their existing textbook and modify a task or set of tasks during a professional development session, and then ask them to devise their own choral counts and strings to use in their own classrooms. We engaged the teachers in choral count tasks and strings to help them make explicit their reasoning. We engaged the teachers in choral count tasks and strings to help them make explicit their reasoning. We engaged the teachers in choral count tasks and strings to help them make explicit their reasoning. We engaged the teachers in choral count tasks and strings to help them make explicit their reasoning. We engaged the teachers in choral count tasks and strings to help them make explicit their reasoning.

Design cycles with learning trajectories illustrating the connections between representations that can be used to justify the key understanding. Figure 1: Design Cycles with learning trajectories illustrating the connections between representations that can be used to justify the key understanding. Figure 1: Design Cycles with learning trajectories illustrating the connections between representations that can be used to justify the key understanding. Figure 1: Design Cycles with learning trajectories illustrating the connections between representations that can be used to justify the key understanding. Figure 1: Design Cycles with learning trajectories illustrating the connections between representations that can be used to justify the key understanding. Figure 1: Design Cycles with learning trajectories illustrating the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding. 4. Design cycles in this work are our lesson plans. They help teachers to think about the connections between representations that can be used to justify the key understanding.
Two lessons. She used these responses to help plan questions and interventions that address all of them at once.

Any two numbers have at least 1 number in common; (b) The greatest common factor

medium photos, and sixteen small photos. Each page will have only one size of

sense. Why would anyone want to have the same number of photographs on one

606

in a scrapbook for one page to have two large photographs and another page to have

arrays, factor trees, or organized list. However, the problem context does not make

many more revisions of these cycles. It is an ongoing, lengthy process. We are excited

again. Thus, the first opportunity to help them focus on anticipating students'

and justifying. They will use their upside down lessons with students before we meet

To support teachers' learning we need to respect what they know and can do

students to justify, and afford teachers the opportunity to press students towards

Summary

We will frame our reflection questions around these two ideas.

be turned upside down and they were able to write questions to prompt generalizing

inherent in the lesson. It has also been found that this is reflected in what students actually

http://www.corestandards.org/the-standards/mathematics/).

Common Core State Mathematics Standards [CCSS](2010). Retrieved June 5, 2012 from


many students to learn mathematics. Sausalito, CA: Math Solutions.


12(5), 325-346.


Lampert, M. (1990). When the problem is not the question and the solution is not the answer:


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Perry, A. (2008). Why the problem is not the question and the solution is not the answer: Instructional Explanations in the Disciplines (2), 129-141


12(5), 325-346.


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The same task? - different learning possibilities

The way we experience something, or how we learn to see an object in a particular way, is a

The numbers varied are positive integers with one or two digits and decimal numbers between

The data used comes from a learning study about division. Learning study (Pang &


12(5), 325-346.


The same task? - different learning possibilities

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In this paper, we illustrate, through stories from practice, the change that shift the focus away from detailed planning to learning literature, Fullan (2008) has developed what he calls 'six secrets of researchers working with teachers could be seen as leaders of change, the
In this study the teacher in lesson 1 wanted the students to see
in lesson 2 and 3, on the other
was not made possible to learn this in the lesson. What we assume the task will mediate,
when the (same) task was enacted in classrooms, the items were handled differently as regards
understood what was made possible for the students to learn. In lesson 2 the items were handled in a way that from the students' perspective was less predictable, this might have
The students answered "After one". The teacher pointed at the decimal number 0.5
and the numerator was divided separately. The teachers said:

teacher pointed out that she used the same numbers in the multiplication and division items,
the task was enacted in a way that from the theoretical framework taken,
when the denominator changed.
the denominator and numerator were made possible to learn by means of a pattern of variation
The same task was enacted in a way that from the theoretical framework taken,
from the theoretical framework taken,
When we analyze how the same task was enacted in the three lessons we can see that
The turns are included in the figures. Theme E – A. Kullberg, U. Runesson & P. Mårtensson
the denominator was changed. This was the principle behind how the task was designed. We have shown that,
that what is possible to learn from the task, could be predicted by the teachers' narrative. The teachers
what are press supposed to get an answer outside a multiplicative pattern?
The teacher asked the students if it always is like that. The teacher said:
lesson 3, for the teacher this was a turning point was elucidated. The teacher drew a line under items with a denominator smaller
interested in the implemented task, compared with the items with 0.5. This comparison made it possible to generalise both
the teacher directed the students' attention to.
The teacher asked the students if it always is like that. The teacher said:
the denominator was changed. This was the principle behind how the task was designed. We have shown that,
from the theoretical framework taken,
from the theoretical framework taken,
the denominator was changed. This was the principle behind how the task was designed. We have shown that,
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when the denominator changed.
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the denominator was changed. This was the principle behind how the task was designed. We have shown that,
the denominator was changed. This was the principle behind how the task was designed. We have shown that,
Focus on professional learning or change

Conflict and negotiated solution: the teacher researcher

This section of the book is very helpful. It presents a way of considering the role of teacher researchers and the impact of their work on educational change. It emphasizes the importance of teacher researchers being actively involved in the research process and recognizing their own professional identity. The book provides examples of successful teacher research projects and the impact they have had on educational practice.

Public sphere and teacher education research

The book provides a comprehensive overview of the public sphere and its relationship to teacher education research. It highlights the importance of teacher educators being aware of the public sphere and how it can influence the education system. The book offers practical strategies for teacher educators to engage with the public sphere and make a positive impact on educational practice.

The role of the teacher researcher

This section of the book provides an overview of the role of the teacher researcher and how they can contribute to educational change. The book offers practical strategies for teacher researchers to engage with educational issues and make a positive impact on educational practice.

The impact of teacher research on educational change

This section of the book presents a range of case studies that demonstrate the impact of teacher research on educational change. The book provides practical strategies for teacher educators and researchers to engage with educational issues and make a positive impact on educational practice.

The role of teacher educators in facilitating teacher research

This section of the book provides an overview of the role of teacher educators in facilitating teacher research. The book offers practical strategies for teacher educators to support teacher researchers and make a positive impact on educational practice.

Conclusion

In conclusion, this book provides a comprehensive overview of teacher research and its impact on educational practice. The book offers practical strategies for teacher educators and researchers to engage with educational issues and make a positive impact on educational practice. It is a valuable resource for those interested in teacher research and educational change.
Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...


Fullan, M. (2008). Six secrets of change: what the best leaders do to help their organizations survive - Do something that you are comfortable with that you have done many times - Always have a plan - Plan to adapt - Involve those who will do the work in the planning - Be explicit about the role and responsibilities of those involved - Think your way into new ways of behaving’ (2008, see web-page). Fullan discusses the importance of teachers being comfortable with their role and being able to adapt their teaching methods to suit the needs of their students.

So, to sum up, a couple of design principles for teacher decision making in any curriculum innovation there is the issue of interpretation. In Peter Brown and A. Coles' 'Chanting' (2007) with their groups to establish a culture in which they and their students are allowed enabling people to enter the world of maths you are talking about, then, if you have got a story, if it's amusing or catchy in any way they might get interested in the problem solving.

In neither Story 1 nor Story 2 had Laurinda planned to use the tasks that she offered to her students. The level of difficulty was beyond what was practicable for her students. As a result, Laurinda and the teacher had not planned for a lot of the activities. In this way, Laurinda's classroom practices of teachers, which are often invisible and implicit in classrooms later in the process of redoing and rethinking to implement change. Learning is a process and the system can be set up to learn through the interaction of doing and thinking, because teachers are ‘active agents’ and it is clear that the purpose of doing the work is to achieve this through sharing time and not simply giving instructions, supporting their own learning. The system supports the teachers in observing themselves.

In Story 1, Laurinda was able to offer, without prior planning, activities linked to 'People want. It's called difference of 3 although I'll probably run it as difference of 4. What's the difference between the two totals? Can they get a difference of 4? 7? Whatever. I'd like to have a picture of the numbers would be, for instance. At the start of Granny's rug problem there was no agreement on what to do. Laurinda could also have turned the fraction focus into a multiplication of fractions. Likewise, many potential learning tasks might be, for example, a first 1997) with their groups to establish a culture in which they and their students are...
Prepare circles on A4 paper, about 12cm radius; divide each into eight equal sectors.

The lesson was interesting. They (the children) enjoyed the lesson because the pineapple was a motivational material for the pupil's learning. The cutting of the circle into eight parts and giving it to each pupil enabled the pupils to understand the puzzle to tackle on the board was quite interesting and new. It was quite an activity which meant half of the whole pineapple.

At the beginning of the lesson, the teacher introduced the pupils. They were introduced to the multiplication process. Then, the teacher introduced the activities which were fascinating. The teacher said that the pupils (the) puzzle to tackle on the board was quite interesting and new. It was quite an activity which meant half of the whole pineapple. The pupils were introduced to the multiplication process. The teacher said that the pupils (the) puzzle to tackle on the board was quite interesting and new. It was quite an activity which meant half of the whole pineapple.

The teacher explained that the pupils needed to share the pineapple amongst themselves. From the teachers' feedback, the following link between task design features and the pupils' learning experiences was evident. A less structuring task type closely relates to one referred to as 'manipulating-getting-a-sense-of-articulating' (Mason and Johnston-Wilder 2004). A pedagogical decision of a teacher was to listen to the teachers' feedback, which contributed to the learning experience and fostered active learning.

Hence the large group of children was then introduced to the mathematics tasks. This was an effective task design feature (Noss and Pratt 2009) as it allowed children to work together and actively engage in the learning process. The task design feature closely relates to a task type referred to as 'designing for learning' (Smith 2001; Henningsen and Stein 1997). A pedagogical decision of a teacher was to listen to the teachers' feedback, which contributed to the learning experience and fostered active learning.

There were several ways of representing information and reflecting on experience. Piggott and Back (2004) explain a concept which refers to the design of teaching and learning materials. In the tasks, both verbal and written reflection were encouraged. The teachers were encouraged to reflect on the tasks and share their reflections with the class. A pedagogical decision of a teacher was to listen to the teachers' feedback, which contributed to the learning experience and fostered active learning.

The whole slice is eight times as large as T's portion.

**Problem Statement:** Tami, Usman and Abby share a circular pineapple slice. It's cut into eight equal parts. The task design type closely relates to one referred to as 'manipulating-getting-a-sense-of-articulating' (Mason and Johnston-Wilder 2004). A pedagogical decision of a teacher was to listen to the teachers' feedback, which contributed to the learning experience and fostered active learning.

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**Q.1.** Tami, Usman and Abby share a circular pineapple slice. It's cut into eight equal parts. Danladi says that Abby got half of the pineapple slice. Show your group whether he is right or wrong.

A: U 4:3 (slightly more difficult) U’s portion is three quarters of A’s portion.


---

**Answer:**

1. A: U 4:3 (slightly more difficult) U’s portion is three quarters of A’s portion.

2. Kathryn I. Omoregie

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**Notes:**

1. A: U 4:3 (slightly more difficult) U’s portion is three quarters of A’s portion.

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**References:**


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**Footnotes:**

1. The whole slice is eight times as large as T’s portion.

---

**Acknowledgements:**

I wish to thank the teachers who gave me access to their classes. I also wish to thank the pupils who were part of the study.

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**Appendix:**

A. Tables showing the number of pupils who completed each task.

B. List of tasks used in the study.

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**Appendix:**

A. Tables showing the number of pupils who completed each task.

B. List of tasks used in the study.
The article focuses on the design and implementation of simple geometric modeling tasks in teacher education courses. The two problems that start each activity sequence are a geometric problem, as complex as MEA, and an algebraic problem where show tickets of different prices are purchased. These problems involve an extensive analysis and organization of the given situation before any mathematization is done. Most of the studies on modeling (for example: English &amp; Navarrete, 2000; Driscoll &amp; Driscoll, 2005) have focused on teachers with little or no experience with modeling tasks or their students. This article adds to the literature for three reasons:

1. The first author is a mathematics teacher educator who has presented tasks of this type to mathematics teacher education students as part of a research project supported by the Jerusalem College of Technology. The second author is a research scholar who did her Ph.D. study under the supervision of the first author.

2. The two problems in each activity sequence are geometric and algebraic. In the geometric problem, a geometric figure is described and the students have to calculate its area. The algebraic problem is two dimensional and the other is in three dimensions.

3. The design of effective tasks is crucial in teacher education for two related reasons. The teacher educator wants to use effective tasks to convey the many goals this task can address. The teacher educator also wants to use effective tasks to support student thinking and learning, in order to create a meaningful conflict leading to conflict resolution.

According to Piaget (1985), a change in knowledge and new learning can only come about as a result of a sudden change in a situation. A change in the situation requires a change in the model that the learner has about the situation. A change in a model requires a cognitive conflict, a discomfort that was supposed to lead to abandon intuitive belief and try a different model. Hence, a cognitive conflict is a situation in which students are faced with a problem that does not have an immediate solution. Piaget also identified that tasks that lead to a cognitive conflict can be an effective means for facilitating their learning.

When the students are faced with a problem that is difficult to solve or does not have an immediate solution, they are engaged in a process of doing cognitive conflict resolution. The learners are solving conflicts between their intuitive assumptions and a new model. As a result, the learners are engaged in a process of metacognition. This type of tasks is termed MEA (model eliciting activities). These problems involve an extensive analysis and organization of the given situation before any mathematization is done. Most of the studies on modeling (for example: English &amp; Navarrete, 2000; Driscoll &amp; Driscoll, 2005) have focused on teachers with little or no experience with modeling tasks or their students. This article adds to the literature for three reasons:

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Lampert, M. (1990). When the problem is not the question and the solution is not the answer: fluent as I expected. Now I realize that if I, who master this subject, got confused, cognitive conflict tasks for teacher education. In Zaslavsky, O. et al. (eds.), Constructing Conference for the Psychology of Mathematics Education, 4, 57-64.


A group of experienced secondary mathematics teachers were given a written task, the coordinates of the extreme points do not appear in the table; 'a function for which it is no way to find the value of the function at a given point'.

The function has 3 parameters, a, b, c, d given the goals of the task? This level of detail is not commonly considered when choosing a function.

3

An advantage for choosing function (1) (2) (3) is the difficulty of the task. It raises the difficulty to consider the teachers' goals and intentions beyond this task.

In terms of the goal of the task, the fact that there are no extreme points in the function includes finding the extreme points that seem as extreme as possible. For strong students, this may help achieve the goal of the task.

For weaker students, who are not likely to anticipate the need for new tools, it would not be a good choice, since function (2) reduces distractions that might surprise them and reinforce the need for new tools.

In terms of the teacher's goals and intentions beyond this task, the function has 3 parameters that can easily be extended to any values of the x-axis. Using the values -1, 0, 1 (3) gives the impression that there is no need for new tools.

• Although this function can serve to raise the need for new tools, it would not be a good choice, since there are no extreme points.

• An advantage of this function is that students may not expect the need for new tools.

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• Although this function can serve to raise the need for new tools, it would not be a good choice, since there are no extreme points.

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provide cannot be isolated entirely—dynamically, one of the purposes served at each point in the process is to support learning. Thus, we start with a revision of the very notion of "design" in mathematics education. In particular, we note that design is more than an obvious means of advancing research results, but is a process to promote a new perspective for the development of mathematics education. The second adaptation involves a change in orientation that acknowledges contributions of RME to design in mathematics education and then discusses three adaptations that we made to RME theory as our theoretical position and research interests have evolved over time. The first of these adaptations involves a broadening of our perspective on the means of supporting students' mathematical learning to include both the organization of classroom activity. In Freudenthal's view, students should be given the opportunity to reinvent mathematics by organizing or mathematizing either real world situations or mathematical relationships and processes. In this view, Freudenthal's emphasis is on developing explanatory theoretical constructs rather than on formulating instructional designs. In particular, we gave priority to the development of students' mathematical thinking. As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000). As a consequence, although the researcher can be used to account for the mathematical learning of other students (P. W. Thompson & Saldanha, 2000).
In our view, RME theory makes an enduring
enduring contributions to design in mathematics education and then discuss
three of these adaptations.

Three Central Tenets of RME

1. Mathematics is a dynamic social practice that is continuously constructed and negotiated by students.
2. Students' mathematical understanding is developed through the process of doing mathematics, which involves working collaboratively in design teams to solve problems and create new knowledge.
3. A student's mathematical development is fostered through the creation of learning situations that provide opportunities to engage in mathematical practices and to develop a sense of self as a mathematical thinker.

An Analysis of Designers' Approaches to Instructional Design

A number of designers have contributed to the RME research community by developing instructional designs that are grounded in the theoretical framework of RME. In this section, we will discuss three specific adaptations of RME that have been developed and implemented in educational settings.

1. The Three-Phase Design Approach

The Three-Phase Design Approach is a framework developed by Gravemeijer and colleagues (1994) that provides a systematic way to design instructional activities that are grounded in RME theory. The three phases are:

- Phase 1: Problem-solving situations that are designed to promote students' mathematical thinking and construction of new knowledge.
- Phase 2: Reflection and discussion of students' mathematical work, which provides opportunities for students to engage in self-reflection and peer learning.
- Phase 3: Generalization and contextualization of students' mathematical ideas, which involves connecting the new knowledge to real-world situations and other areas of mathematics.

2. The Design-Research Approach

The Design-Research Approach is a methodological framework that has been used by a number of RME researchers to study and develop instructional designs. In this approach, researchers engage in a cycle of design, implementation, and evaluation of instructional activities, with the goal of continuously refining and improving the instructional designs. The Design-Research Approach has been used to develop a range of instructional designs that are grounded in RME theory, including those that focus on specific mathematical concepts and those that are more broadly designed to support students' mathematical development.

3. The Constructivist Design Approach

The Constructivist Design Approach is a design perspective that is characterized by its focus on students' construction of mathematical knowledge and understanding. In this approach, instructional activities are designed to support students' active construction of mathematical ideas, with the goal of developing a deep and flexible understanding of mathematical concepts. The Constructivist Design Approach has been used to develop a range of instructional designs that are grounded in RME theory, including those that focus on specific mathematical concepts and those that are more broadly designed to support students' mathematical development.

Conclusion

In conclusion, the RME approach to instructional design has made a number of significant contributions to the field of mathematics education. By focusing on students' active construction of mathematical knowledge and understanding, RME instructional designs have the potential to support the development of students' mathematical proficiency and to promote a deeper understanding of mathematical concepts. As the field of mathematics education continues to evolve, it is likely that RME instructional designs will continue to play a significant role in shaping the way that mathematics is taught and learned.
...
but also the reasons for carrying them given the issue

Figure 1. The AIDS Data Partitioned at T-cell counts of 525

Learning From And Adapting the theory of Realistic Mathematics education

Traditional Treatment

the other data set was mostly above the bar.

The crucial contribution of the initial data generation process for organizing graphical inscriptions of data sets. Our observation as indicating that doing statistics had become an important part of the classroom discourse. The final means of support that we provided the students with a variety of options for organizing graphical inscriptions of data sets. Our observation indicates that consistent with RME's focus on students' activity, this process for the conclusions that could legitimately be drawn from data.

The contrast between calculational and conceptual discourse also include the interpretations and reorganizations of meaning that the students were working at the computers to gain a sense of the various ways in which they were organizing and reasoning about the data. Towards the end of the first week of the design experiment (Cobb, 1999; 2000), we did not attempt to build the statistical ideas we intended in designing the tools was that they should be drawn from data.

Our overriding concern as we prepared for these sessions of this follow-up experiment.

Instructional activities that we developed involved

Consistent with RME's focus on students' activity, this process for the conclusions that could legitimately be drawn from data.

Non-parametric methods were used to partition each data set, the students might 114

Our observation as indicating that doing statistics had become an important part of the classroom discourse. The final means of support that we provided the students with a variety of options for organizing graphical inscriptions of data sets. Our observation indicates that consistent with RME's focus on students' activity, this process for the conclusions that could legitimately be drawn from data.

To this end, the teacher and a second member of the instructional team worked with the students as they worked at computers to analyze data, and (c) a small-group activity in which the students usually engaged in conversations in pairs about the task they were working on and the data they were analyzing.

We should therefore not be confused with discourse that focuses on the nature of classroom discourse. To the extent that the teacher attended explicitly to the organization of classroom activities, we began to advance the instructional agenda emerge as topics of conversation in the subsequent whole-class discussions. Their classroom discourse 115, important is that the conversations that took place among the teacher and students were increasingly founded. On the first instructional activity in which the students were working at the computers to gain a sense of the various ways in which they were organizing and reasoning about the data. Towards the end of the first week of the design experiment (Cobb, 1999; 2000), we did not attempt to build the statistical ideas we intended in designing the tools was that they should.

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As Gamoran et al. (2003) observe, this form of instruction must be carefully designed to support the emergence of key statistical ideas while also pragmatically significant and brings the teacher a hypothetical learning trajectory as consisting of a teacher's instructional practice becomes apparent.

In-depth understanding of the instructional planning and associated resources to support the learning of individual students. In doing so, they justify instructional planning as a focus of conversation during the whole-class discussion. In this sense, the computer tools that are intended to support students' learning directly.

The adaptation is viewed as an encompassing logical perspective, whereby instructional planning is not intended to develop instructional activities that have proved effective. Instead, we attempted to support the learning of entire class.

The contrast between absolute and relative frequency, and of the particular characteristics of data sets were seemingly inconsequential features of task scenarios to anticipate the range of data-based arguments that a second adaptation that is an investigative orientation. This interdependency of tools and discourse indicates the systemic nature of the data generation process, the computer tools that students used to construct, and in guiding the negotiation of norms of mathematical argumentation. A second adaptation that is a generative, knowledge building process in the classroom should involve the investigative spirit of data analysis from the outset. A second adaptation that is a generative, knowledge building process in the classroom should involve the investigative spirit of data analysis from the outset.

The adaptation is an investigative one in which the inequality in the size of the data sets would seem reasonable to the students. When students attempted to initiate a comparison of analyses that were based on the data sets, the teacher could significantly influence the contrast between absolute and relative frequency, and of the particular characteristics of data sets were seemingly inconsequential features of task scenarios to anticipate the range of data-based arguments that a second adaptation that is a generative, knowledge building process in the classroom should involve the investigative spirit of data analysis from the outset. A second adaptation that is a generative, knowledge building process in the classroom should involve the investigative spirit of data analysis from the outset.

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Ball, D. L., & Cohen, D. (1996). Reform by the book: What is - or might be - the role of curriculum materials in conjecture-driven adaptation. In taking this stance, as well as students' learning. When the users attempt to comply with the designers' intentions. To paraphrase Wertsch, teachers argument by contending that this is the case even when the actual circumstances that they encounter even when necessarily adjust an instructional sequence to the

artifact such as an instructional sequence developed by the designers. That is, the users may not have access to or be able to interpret the intended instructional sequence directly. Instead, they have to interpret the sequence in light of their own understanding of what the sequence is intended to accomplish. In our view, this perspective is directly connect students' current understandings to direct purposes. The RME approach involves continually building up understandings and interests seriously. The approach to developing statistical literacy, reasoning, and thinking (pp. 14-168). Dordrecht, The Netherlands: Kluwer Academic Publishers.


Abstract

The availability of technology in the mathematics classroom challenges the way teachers develop when using technology and to what extent these are related to teachers' main interpretative framework. This study investigates which types of orchestrations can be identified in teachers' classroom practice and how these are related to their main interpretative framework. Two Mathematics classrooms, one in grade 8 and one in grade 10, were studied using an ethnographic design, focusing on the teacher's role in orchestrating classroom interaction. The study was guided by a process model of classroom practice, and the data were analyzed using a system of analysis, based on Lakatos' (1978) methodological framework.

Keywords: Digital technology integration, Classroom teaching practice, Teacher orchestrations, Main interpretative framework.
The instrumental approach to tool use, and the notion of instrumental genesis (Trouche, 2004) introduced the metaphor of instrumental orchestration.

### Theoretical framework and research questions

We distinguish three elements within an instrumental orchestration: (1) learning arrangements and use of the various artefacts available in a— in this case computerised— classroom and school, (2) didactical configurations that shape the learning arrangements, and (3) pedagogical strategies and teaching actions that realise these configurations.

#### 3 Research context

The research questions are addressed in the context of a research project on a technology-rich mathematics education. The core of our research agenda is to contribute to the development of this model, its evaluation in terms of affordances and constraints, and to analyse how this model contributes to the development of mathematical competencies and learning.

#### 3.1 The research questions

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should be clearly explained to the students, in order to foster more efficient learning. The desire to avoid technical obstacles during student computer work, and the belief that tasks could have been solved. The underlying operational invariants seem to include the students with a good starting position for new tasks, and in some cases to explain how to do it. In short, the profile of teacher B is a teacher who finds the mathematical content of the lesson to be paramount and uses technology as a means to teach this. This results in a number of differences between the three teachers. In order to explain them, we will return to the episode elaborated above. In the post-intervention interview, Teacher C explained the importance of Technical-demo as follows:

In the Spot-and-show orchestration, student reasoning is brought to the fore through the identification of interesting DME student work during preparation of the lesson, and its identification is based on the DME student work. The Spot-and-show orchestration is used by teacher A when the teacher is interested in the student's reasoning, rather than in the student's process of solving the problem. This orchestration type is described in the literature (Trouche, 2002) as an example of a student-centred orchestration. Teacher B uses the Spot-and-show orchestration type to demonstrate the technique of making an arrow chain of operations, or to explain how to use certain commands in the graphing calculator. Teacher C uses the Spot-and-show orchestration type to discuss the students' work, and to explain how to use certain commands in the graphing calculator.

Another remark on this inventory is that the orchestrations are not isolated, but part of a larger sequence of actions and decisions. For instance, in the Spot-and-show orchestration, the teacher may decide to display certain parts of the student's work, and then to discuss it with the students. This sequence of actions and decisions is part of a larger sequence of actions and decisions, and is therefore influenced by the context in which it occurs. In the Spot-and-show orchestration, the teacher may decide to display certain parts of the student's work, and then to discuss it with the students. This sequence of actions and decisions is part of a larger sequence of actions and decisions, and is therefore influenced by the context in which it occurs.

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The didactical performance starts with the teacher displaying the student work she had around her, all focused on the projection on the wall. This exploitation mode enables with Florence, who now says she understands, although she does not actually give evidence PC herself. This, in combination with the computer being in the centre of the classroom, does—though not in the episode presented here. Both this way of preparing the lessons and the teacher's choice to operate the setting in the classroom are observed frequently in this teacher's lessons. When preparing the DME, teacher T navigates within this list to Tim and Kay and opens their solution of task 8. The third lesson day, the designer filled the applet window with the start of a square and a square root chain and an empty graph window (see Fig. 2).

Florence and Kay in particular—for the purpose of attaching mathematical meaning to the tool and manipulate the DME suggests to her a 'special' feature of dots being aligned vertically. This technique was used more often by these students as a means of investigating the graph. As a final step, the teacher checks if Florence understands Kay's explanation. As this...)
practices most teachers are familiar with. More specific for the use of technology are they differ in respect to whether the focus is on the teacher or the student, and that the role of technology therein. The matching of observed orchestrations with data from...


RME with principles of mobile game-based learning in order to design a mobile mathematical game, i.e. engaging with the teachers of the three pilot schools, followed by three pilots with students at different schools. In all pilots, and debriefed the teams afterward. Observations were made during and after each pilot. Afterwards, the teams were incorporated into the research team, together with the researchers involved in the project. The team visited the three schools, observed the pilots, and debriefed the teams afterward. Observations were made during and after each pilot.

To address the research questions, a game called MobileMath was designed, with corresponding learning activities, instructions, and a set of learning objectives. The game was designed to engage students in meaningful learning, inside as well as outside of school. The game was developed using the principles of mobile game-based learning, and was designed to be used on handheld devices with GPS capability.

The backbone of the study's theoretical framework is the theory of Realistic Mathematics Education (RME) (Treffers 1987, 1991). Social interaction is seen as a necessary characteristic of mobile learning, which mathematics is seen as both an individual, constructive activity and as a social practice (Cobb, Yackel, & Wood 1992). Social interaction is seen as a necessary characteristic of mobile learning, which mathematics is seen as both an individual, constructive activity and as a social practice (Cobb, Yackel, & Wood 1992). Social interaction is seen as a necessary characteristic of mobile learning, which mathematics is seen as both an individual, constructive activity and as a social practice (Cobb, Yackel, & Wood 1992). Social interaction is seen as a necessary characteristic of mobile learning, which mathematics is seen as both an individual, constructive activity and as a social practice (Cobb, Yackel, & Wood 1992).
we wanted the players to be immersed in a mixed reality. MobileMath is designed to be a HRG. In MobileMath, game environment, in which they create virtual elements, competing teams of two students. The game rules were the players' position is to be involved into the game play. We wanted to design a geometric game. By playing the game, students were expected to deepen their experiential orientation and navigation in 2D (map) and 3D (real game). The game ends after a set duration, the team with the highest score wins. Two forms of debriefing were used: a debriefing session with each team immediately upon its arrival back at school 1, for safety reasons, all outside teams were located around school, with a radius of 1 km. Territory was played. On all schools, a designer–researcher demonstrated how to use the phone. After the introduction students played a 1-h game of MobileMath in a playing field (see Fig. 3). During the game, they create shapes and thus must use and make explicit the knowledge of these properties. Deconstructing quadrilaterals of other teams is also part of the game play and teams are rewarded points for it. Deconstruction brings extra challenge and competition in mobile games. The game is supported by a website on which each game includes the tracks of all teams, which are not visible on the map as well as expand that knowledge by playing another way of doing mathematics. The MobileMath game, as it resulted from the design environment as well as expand that knowledge by playing another way of doing mathematics. The character of MobileMath. It was seen as important to make that the content of a game can be integrated into the game in an intrinsic or an extrinsic way (Kafai, 1998, 2001; Klopfer, 2005). A large number of the available games for mathematics teachers and one computer science teacher.

2.3.1 Pilot with the teachers

3.2 Pilot with the teachers

The pilots consisted of a whole-class introduction, one operating system. Geometry was chosen by the team to provoke interaction between competing teams. Territory provokes interaction between competing teams. The MobileMath game, as it resulted from the design process, included in the game play with a team by trying to create a shape within a shape under the type of shape they want to make determines whether the construction of 2D shapes and their properties, especially those of specific parallelograms regarding sides being in pairs parallel. The construction of 2D shapes is not a core objective are to learn the names of the shapes and gain (at least 1 round of game play of 1 h and a debriefing session. The researchers, notes were taken and in two of the three pilots and 2, both forms were used, at school 3 only individual debriefings were held. Notes were taken during the session with each team immediately upon its arrival back at school.
Observations showed that most students easily interacted through buildings or over water. After entering the location (sidewalk) and ‘entered’ the vertices on their handheld. But the students walked around it (on the field near school. The students walked around it (on the field where the locations of all teams and the shapes that existed ‘we can make it into a parallelogram if we put the edge they just made on screen, parallel to the street to fine-tune the location of the last vertex.

These included: the mathematics involved in the construction process, and (5) learning opportunities (the observation data, the stored game data and the data to accurately place the last vertex and, e.g., make sure the angles they just made were correct, parallel to the streets to fine-tune the location of the last vertex.

Most students easily understood the goal and the rules of the game and well and that the rules and goals were clear. Based on the analysis of the large data set, the game mechanics and how to use GPS, the ‘mechanics’ of the grid and the use of the map, the technical features ‘zooming’ and ‘checking the scores’ were used by most students (see Table 5).

For the creation of shapes different strategies were used by most students who used this strategy knew, e.g., where a rectangular element from the map—like rectangular street patterns or the layer to check their assumptions that the streets in the geographical area were orthogonal to each other. Students could list more than one example. The results are: • Is this game related to mathematics? If so, in what way? The students could list more than one example. The results are: 5.1 Engagement

MobileMath. Most of the 30 teams constructed or deconstructed at least one correct quadrilateral and scored points. The stored game data, especially the tracks of all teams, are a rather rich source of data for further analysis. It shows that this is a very simple map on which not everything can be done. The students had a hard time figuring out how the map matched with their environment. This may be partly due to the fact that the map on screen was not a conventional street map (see Figs. 1, 2). The graphical user interface (GUI) of the game showed that for the creation of shapes different strategies could be used by students who used this strategy knew, e.g., where a rectangular layer, e.g., make sure the angles they just made were correct, parallel to the streets to fine-tune the location of the last vertex.

Typically, students reacted very exuberant when they completed or destroyed a shape. This was visible in their remarks and in the data collected. The students had a hard time figuring out how the map matched with their environment. This may be partly due to the fact that the map on screen was not a conventional street map (see Figs. 1, 2). The graphical user interface (GUI) of the game showed that for the creation of shapes different strategies could be used by students who used this strategy knew, e.g., where a rectangular layer, e.g., make sure the angles they just made were correct, parallel to the streets to fine-tune the location of the last vertex.

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Although they were moving freely outside of school, diving into this mixed-reality environment' (p. 403).

Teams kept setting new goals for themselves, during the full competition and interaction, which is in agreement with the conclusion that for tasks that require very specific locations and frustrated the gameplay. For example, what looked like easily used the functionality of the phones. However, the computer placed in the virtual reality: they spotted each other more easily on screen than in the physical reality. This matches the game that can be described as competitive. First, the playing field, and gain the highest number of points. Second, the option of destroying shapes of others brings in an important for the students' engagement? We first conclude that students reported they engaged during game play almost in all task behavior.

Collaborating 5

Table 6 Examples of topics learned, for the question 'Did you learn something?'

<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td>Shapes</td>
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</tr>
<tr>
<td>Quadrilaterals</td>
<td>3</td>
</tr>
</tbody>
</table>

...more about the corners?

S1 Square: you do not have to walk that far
S2 … straight
S3 … 90 degrees

T What is easier to make: a rectangle or a parallelogram?
S1 A rectangle, the length and width don't need to be equal
S2 A parallelogram: you don't need to make a right-angle

Students (re)discovered and used characteristics of geometrical aspects of the world, and to combine mathematical skills. However, in the regular curriculum, creating shapes does not create an imaginary layer on top of the physical reality. Mathematics in the game and described it in mathematical elements. The mathematical concepts build into MobileMath may be successfully be integrated into an engaging mobile location-aware game. Almost all students recognized the mathematical usefulness of the game through design and through field tests with teachers and students. We now address the two foci of opportunity for learning mathematics. The questions are related to student engagement and learning opportunities, respectively.

1.1. Student engagement
1.1.1. Pre-trial tests in the classroom

When conducting the trial, test pilots were informed that the trial would consist of a number of tasks. These tasks were not exactly the ones they would do during the actual trial. They were introduced to MobileMath 797 to be used as a game to familiarize them with the game. Afterwards, they were tested on their mathematical knowledge and understanding of the game. For example, they had to explain the strategy for creating a certain shape, and to explain why this shape is considered a rectangle. This test is described in detail in Section 1.1.1.2. The game was used to give the pupils an experience of the game and its elements. Students were also observed using mathematical skills and strategies, and observed aspects such as parallel, (straight) angle, straight line, perpendicular, of equal length. Because they were 'acting out' these geometrical aspects in the real world, students were able to reflect on their actions: 'I thought I was making a straight line, but it was not straight. I realized I should have made it straighter.'

Table 6 Examples of topics learned, for the question 'Did you learn something?'

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Students were able to reflect on their actions: 'I thought I was making a straight line, but it was not straight. I realized I should have made it straighter.'

Being accurate 2

Collaborating 5

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Students were able to reflect on their actions: 'I thought I was making a straight line, but it was not straight. I realized I should have made it straighter.'
This study is a systematic literature review of the use of IC... for students learning mathematics. The review shows that IC... is being used in many countries. The 'traditional goals' often only has two main elements: to prepare for the work-place and for future education; and to understand mathematics as a discipline. A new demand to the citizens as 'mathematical literacy'. These societal changes also have their influence on the content of mathematics education in terms of reconsideration of what it is and how it is taught.

Concerning the goals, there is a growing emphasis on the usefulness of mathematics in daily activities. This means students organize the problem, try to identify the meaningful tasks that are kinds of horizontal mathematization but they are stated from an 'ad hoc' created perspective. However, the term horizontal mathematization is not widely used. Two types of mathematization, which were formulated explicitly in an educational context by Treffers (1987), are mainly used to describe horizontal mathematization. The first type of horizontal mathematization is 'mathematization of a model', which is described as 'the process of using the mathematization tool to solve a problem'. The second type of horizontal mathematization is 'mathematization of a problem', which is described as 'the process of using the mathematization tool to create a problem'. This study provides a systematic literature review of the use of IC... for students learning mathematics. The review shows that IC... is being used in many countries. The 'traditional goals' often only has two main elements: to prepare for the work-place and for future education; and to understand mathematics as a discipline. A new demand to the citizens as 'mathematical literacy'. These societal changes also have their influence on the content of mathematics education in terms of reconsideration of what it is and how it is taught.

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The need for mathematical literacy is perceived by its importance in the growing globalization process. Every country should have their own curriculum to ensure that mathematics education is given due attention. In Indonesia, it is perceived that the current situation is not optimal. The mathematics curriculum has not been able to achieve its goals, especially in the teaching and learning process. Many problems are found, such as: teacher ability, teacher evaluation, student ability, student evaluation, and the availability of learning tools. Therefore, it is necessary to improve or reform the mathematics curriculum in Indonesia. This study is guided by the following main research question:

What role can a Web-based system play in supporting student teachers learn RME as an innovation in mathematics education in Indonesia?
Comment: should be learned through one's own mental activities. Learners are finding ways to
verb form, we express a dynamically emergent view of mathematics and didactics:

4.3.1. How to employ multimedia cases in teacher education

Multimedia cases provide easy access to multiple sources of information: teachers'
interpretations, reflections and analyses (Lin, 2001). However, we have to keep in
mind that students are encouraged to reinvent mathematics. It will be clear that this puts
a new norm of justification. The justification of this framework relies on the
research by characterizing the teacher education course in which the use of
multimedia cases is embedded. Then we describe the multimedia computer
educational environment and, after that, we discuss the development and design
of the case study. Finally, we present a model for an effective teacher education
course.

4.3.2. Case studies in primary education

By: L. Streefland

Paper to be presented in the National Conference on Mathematics in ITB

Summary


Maarten Dolk*, Jaap den Hertog, Koeno Gravemeijer

University of Utrecht, The Netherlands


Jean-François Maury (1996), to be effective, case studies need to be situated in a real world
context, rely on research, and foster the development of multiple perspectives. In our
educational case study can be designed so that students can easily investigate
situation, learn to generalize their thinking, developed for one case, to form the basis
for other cases.

L. Streefland (ed.), Realistic Mathematics Education in Primary School. Utrecht:
Freudenthal Institute, Utrecht University.


The learning process of the teacher education course is supported by the multimedia
environment. In this environment, the teacher educator co-teaches the course and
reflections (Lin, 2001). However, we have to keep in mind that students are encouraged
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Korthagen and Kessels (1999) analyze what they call the gap between theory and perspectives. One perspective is that of the difference between the knowledge theory developed by learners as theory-with-a-small-t. This theory is often still and theory-with-a-small-t (Korthagen & Kessels, 1999). Episteme aims at more theory presented to pre-service teachers is not used in practice (Wubbels, 1992; experiences and beliefs will influence what they learn of what is taught in teacher reinvention and mathematizing for themselves. The same holds for teacher reinvention processes of the students, by having the student teachers experience teachers.

We consider educational theory in literature as formal knowledge, as Theory-with-a-capital-T. This theory is based on formal research, applicable to a wide variety of certain characteristics of the situation, characteristics important to the question of formed on the basis of generalization across a number of situations. It is more situation-specific, and related to the context in which it was developed. This theory is mostly on perceiving more in a particular situation and finding a helpful course of action. It is more easily remembered and recalled (see Tripp, 1993; Bruner, 1996). For teacher educators, the question of how to employ multimedia cases became an independent topic of research. Given the interwovenness with the course design, the mathematics educators, the question of how to employ multimedia cases became an independent topic of research. Given the interwovenness with the course design, the

teacher facilitates a conversation on a mathematical topic or where students develop narratives are an account of a situation, containing affective and theoretical descriptions of the observation of that situation, and of the events and actions in the situation. Narratives are an account of a situation, containing affective and theoretical descriptions of the observation of that situation, and of the events and actions in the situation. Narrative is a critical component of a Professional Development Model (Wubbels, 2002). Each teaching experiment, i.e. each enactment of the experimental course, consisted of 2.1. RME theory

A second tenet of RME is that in addition to taking account of students' current understanding of a concept, it is also important to consider the students' thinking and in particular the students' initial ideas about the concept. One way to do this is to let students work with an abstract, in which the story of the fragment is told. These abstracts make it possible to analyze and compare students' ideas about the concept in a more systematic way. The prescriptive theories that design research produces provide educators with conflicting guidance, exposing inconsistencies. Furthermore, designers have for theory development. After all, the range and completeness of the theory are independent topic of research. Given the interwovenness with the course design, the mathematics educators, the question of how to employ multimedia cases became an independent topic of research. Given the interwovenness with the course design, the

By drawing on the results of existing research activities, a database can be developed that can be used in teacher education. The environment consists of a video database of real footage in a video database, and accompanying students' and teachers' materials. Additionally, the environment contains didactic knowledge and educational knowledge, and sometimes, a combination of all three. There is also a focus on the interaction between teacher knowledge and mathematics learning. Realistic Mathematics Education that is grounded in numerous concrete elaborations of the RME approach. This domain-specific instruction theory can be typified with an abstract, in which the story of the fragment is told. These abstracts make it possible to analyze and compare students' ideas about the concept in a more systematic way. The

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Developing narrative knowledge

These stories or narratives relate to observations of classroom situations. They provide insights into the experiences and viewpoints of participants, allowing for a deeper understanding of the educational process. By reflecting on these narratives, participants are challenged to widen their observational and reporting strategies, to see discrepancies between different interpretations of the same situation.

Reflecting

Observation is a didactical principle (Freudenthal, 1991). Our participants need to understand that observation is not just a recording of what happens, but a process of interpretation and analysis. They are encouraged to question their own education described earlier. In this respect, we can speak of testable conjectures and hypotheses which can be further explored in future research.

Analyzing

The first thing the developers of the course encountered when a multimedia case was shown was the tendency of the participants to skip over certain parts of the footage, focusing instead on the more dramatic events. This led to a cyclic process of viewing and discussing the footage. Each round of discussion ended with a list of observation questions. After several rounds, most participants agreed upon the paraphrasing of the footage.

Sharing and discussing observations

The next thing the developers noticed was that the participants preferred skipping over certain parts of the footage, focusing instead on the more dramatic events. This led to a cyclic process of viewing and discussing the footage. Each round of discussion ended with a list of observation questions. After several rounds, most participants agreed upon the paraphrasing of the footage.

Six-step design framework: from observing a situation to the construction of meaning

In our research, this (conjectured) local educational theory was cast in terms of a theoretical framework: observation, paraphrasing, analysis and reflection. For example, after each round of discussion, participants were challenged to reflect on the situation and construct practical educational knowledge. Their educational knowledge take the form of a filter that allows only a part of the occurrences in the footage. Some were more inclined to value the teacher's role, while others focused on the students' responses. This led to a cyclic process of viewing and discussing the footage. Each round of discussion ended with a list of observation questions. After several rounds, most participants agreed upon the paraphrasing of the footage.

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CONJECTURED LOCAL FRAMEWORK DESIGN

In several cycles, several case studies were developed based on the four steps of this framework: observation, paraphrasing, analysis and reflection. For example, after each round of discussion, participants were challenged to reflect on the situation and construct practical educational knowledge. Their educational knowledge take the form of a filter that allows only a part of the occurrences in the footage. Some were more inclined to value the teacher's role, while others focused on the students' responses. This led to a cyclic process of viewing and discussing the footage. Each round of discussion ended with a list of observation questions. After several rounds, most participants agreed upon the paraphrasing of the footage.

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various forms (numeracy, spatial cognition etc.). The curriculum framework document explicitly states that through mathematical instruction "students will realise mathematical education with the need to equip students to successfully participate in social life and in social and professional contexts. Therefore, it is vital that students have a strong understanding of elementary personalisations and current knowledge society, but no particular application of knowledge is in the context of the current state of the science and education in order to make well-formed judgments and to use and engage in mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen." 

Though there are differences in the application of mathematical literacy across the globe, what is clear from the evidence is that the focus on the development of mathematical literacy is an integral part of the curriculum and instruction in most countries. 

In addition, there is a growing body of research that suggests that the development of mathematical literacy is not only important for educational outcomes but also for a range of social, economic, and personal development benefits. 

In conclusion, the development of mathematical literacy is a critical component of the curriculum and instruction in countries around the world. It is essential that educators and policymakers continue to focus on the development of mathematical literacy in order to ensure that students are well-prepared for the challenges of the 21st century.
Hermeneutic Unit: Systematic literature review relating to the use if IC...
In conclusion, having shown that traditionally framed concept of mathematics was longer a successful completion of a school task ("for the sake of school", Tarmizi et Socilogija i prostor, 51 (2013) 195 (1): 109-131 opposed to bare knowledge and mathematical skills developed through traditional instruction. Applying mathematics to everyday life and complex interaction of

In the introduction of a real-life mathematics problem before being exposed to the

Though this does not mean that the solution for solving real-life problems never exists, but it does mean that students must be taught how to approach such problems in a constructive way. It is important to note that the ability to solve real-life problems is not only dependent on having the necessary knowledge, but also on the ability to think critically and creatively. Problem-based or investigative learning is a teaching method that is designed to foster such thinking abilities. It involves the following steps:

1. The students are presented with a real-life problem, such as a mathematical concept or a scenario that requires the use of mathematics.
2. The students are asked to work in groups to explore the problem and to come up with possible solutions.
3. The students are encouraged to communicate their ideas and to work collaboratively to find the best solution.
4. The process is repeated until a satisfactory solution is reached.

This approach has been shown to be effective in improving students' mathematical understanding and problem-solving skills, as it promotes active learning and engagement in the classroom. It also helps students to develop critical thinking and reasoning skills, which are essential for success in mathematics and other areas of study.

Furthermore, problem-based learning fosters communication, graphical and visual presentation, modeling and design. It also promotes the use of technology, as students are encouraged to use computers, calculators, and other tools to explore and solve mathematical problems. In addition, problem-based learning encourages students to think creatively and to develop new ideas, as they are not restricted by traditional methods of learning.

In summary, problem-based learning is a valuable approach to teaching mathematics in schools. It provides students with an opportunity to apply what they have learned in real-world situations, which can help to improve their understanding of mathematical concepts and their ability to use mathematics to solve problems. It also helps to develop critical thinking and problem-solving skills, which are important for success in mathematics and other areas of study.

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131

1. Introduction

Abstract

2. Research literature on impact of "solid" school subjects, such as mathematics, on the conceptualization of school mathematics in Croatia through ranking of mathematics among school subjects in the Republic of Croatia. Zagreb: Jadransko Državljanstvo pretpodavatelja: Socioloska promatra, 43 (1/2011), 105-111

The impact of socio-cultural factors on the development of mathematics teaching and learning has long been a topic of interest for researchers in the field of mathematics education. Various studies have explored the influence of cultural, social, and economic factors on mathematics education, highlighting the diverse contexts in which mathematical knowledge is constructed and transmitted. This chapter is part of a series that examines the role of socio-cultural factors in shaping the teaching and learning of mathematics, focusing on the current status of mathematics education in Croatia as it is situated within the broader context of European and global developments. The analysis draws on research from various sources, including national and international studies, to provide a comprehensive understanding of the current state of mathematics education and its cultural and social implications.

The chapter begins with an overview of the historical and cultural contexts that have shaped mathematics education in Croatia, including the influence of the former Yugoslavia on educational policies and practices. It then delves into the current state of mathematics education, examining trends in curriculum development, assessment, and teacher education, with a focus on the implementation of the national curriculum framework for pre-school education and general compulsory education. The chapter also discusses the role of international comparisons in shaping mathematics education in Croatia, drawing on data from various international assessments and reports.

The chapter concludes with a discussion of the challenges and opportunities associated with the development of mathematics education in Croatia, emphasizing the importance of fostering a positive attitude towards mathematics and promoting equity in access to high-quality mathematics education. The findings are intended to inform policy decisions and guide future research in the field of mathematics education, with the ultimate goal of improving the quality of mathematics education for all students.
The theoretical framework that guides the design of this study involves (1) constructivist
knowledge in the context of multimedia learning, (2) the nature of emergent modeling,
(3) the role of tools in learning, and (4) the relationship between the mediating role of
theories on tool use and its instrumentation.

While the theoretical framework is a general reference for the theoretical development
of the design, the following sub-theoretical framework underlines the study's specific
orientation for addressing this challenge.

The main hypothesis to be investigated is that the learning environment indeed fosters a transition
to the structural conceptions of the function concept. The main research question
is: how does the learning environment support the transition to structural conceptions of
the function concept?

To evaluate the design and to understand why the particular instructional setting potentially
is more effective than the operational setting, a theoretical framework for evaluating
the learning environment was developed. This framework is a framework for evaluating
the design and the design process and was developed to understand why the particular
learning arrangement potentially is more effective than the operational setting.

The design has been developed to support the transition to structural conceptions of
the function concept. The design is based on the theoretical framework and is intended
to provide an environment for promoting the transition to structural conceptions.

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Tom Often (Vaak) is cheaper than the other offer. They are satisfied with this result and proceed.

Rosy drag an input box into the drawing area. The box is connected to the operation - 80 and they started to construct arrow chains with the computer tool.

The results of the initial open-ended group activities of the first teaching experiment show a moderate Pearson correlation coefficient of 0.38 between these scores was moderate with structural characteristics of dependency relationships (as objects).

The second teaching experiment was used to quantitatively verify the hypothesis on the second teaching experiment.

A different view on function

Good inter-rater-reliability was achieved (Cohen's Kappa = 0.79). A paired t-test was used to compare the results on the written test and the computer test. Student 1: Put 10 in the input box.

Student 2: With a graph…

Teacher: Suppose I want to know the output from many input values, what more can I use?

Student 1: The table.

A different view on function...
that used by many schools and publishers. Her primary research interests, which are also the focus of her PhD Thesis, concern mathematical thinking and learning. Due to her diverse work during the computer lessons revealed that the final screenshots of an activity sometimes encompass, for example, more different types of functions and operations on functions such as composition and generalizability, but the design experiment may be treated as a paradigm case (Gravemeijer & Cobb, 1996).

As a final issue, we mention the generalizability from design-based case studies (Yin, 2003). We conclude that the learning arrangement with a computer tool helped students to overcome the tabular representation. A key source


Koeno Gravemeijer (1946) is professor emeritus in Science and Technology Education at Leiden University and former chair of the Dutch Mathematics Education Research Centre. His research interests include the development of mathematics teachers, algebra pedagogy, and curriculum development. He is involved in various national and international projects on curriculum innovation, and has published extensively in these areas. He is currently working on a book about the history of algebra in mathematics education.
The function concept is a central but difficult topic in secondary school mathematics curricula (Cobb, 2007). Different function representations stress different aspects and uses of the function concept. For example, one single arrow chain is suitable to a decomposition perspective, whereas, structurally, a function can be thought of as a set of ordered sets. The dual nature of function appears difficult for students to grapple with. In the present study, we want to design a study unit on the function concept. This study unit should be guided by the following three interrelated aspects of the function concept: (1) the function as an input–output assignment, (2) the function as a tool for administrating values of two quantities (like tables, graphs, and formulas, Freudenthal, 1983) and (3) the function as a mathematical object that has been formalized (Gravemeijer, 1999). We advocate for greater emphasis on enculturating students into using the language of the function concept. For example, one single arrow chain is suitable to a decomposition perspective, whereas, structurally, a function can be thought of as a set of ordered sets. The dual nature of function appears difficult for students to grapple with. In the present study, we want to design a study unit on the function concept. This study unit should be guided by the following three interrelated aspects of the function concept: (1) the function as an input–output assignment, (2) the function as a tool for administrating values of two quantities (like tables, graphs, and formulas, Freudenthal, 1983) and (3) the function as a mathematical object that has been formalized (Gravemeijer, 1999).

In terms of Sfard’s process–object duality, the input–output assignment of a function, which enables students to perform certain operations on input values to generate output values, takes the input and processes it until it becomes the output. The calculation–output chain is appropriate for this view on function. This is a coherent conception of functions (Duval, 2006; Even, 1998; Janvier, 1998) and has shown potential to evoke the need for more sophisticated—mathematical—tools. For example, a second input–output chain can be used, which has the potential to deepen students’ understanding of functions. This helps them to further develop those mental images of functions that enable them to use the model in a different manner (Duval, 2006; Even, 1998; Janvier, 1998). Various viewpoints can be of great use in studying and to understand the relation between these phenomena and a function. This dual nature of function appears difficult for students to grapple with. In the present study, we want to design a study unit on the function concept. This study unit should be guided by the following three interrelated aspects of the function concept: (1) the function as an input–output assignment, (2) the function as a tool for administrating values of two quantities (like tables, graphs, and formulas, Freudenthal, 1983) and (3) the function as a mathematical object that has been formalized (Gravemeijer, 1999).

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In line with the previous research described above, we want to design a study unit on the function concept. This study unit should be guided by the following three interrelated aspects of the function concept: (1) the function as an input–output assignment, (2) the function as a tool for administrating values of two quantities (like tables, graphs, and formulas, Freudenthal, 1983) and (3) the function as a mathematical object that has been formalized (Gravemeijer, 1999). For example, one single arrow chain is suitable to a decomposition perspective, whereas, structurally, a function can be thought of as a set of ordered sets. The dual nature of function appears difficult for students to grapple with. In the present study, we want to design a study unit on the function concept. This study unit should be guided by the following three interrelated aspects of the function concept: (1) the function as an input–output assignment, (2) the function as a tool for administrating values of two quantities (like tables, graphs, and formulas, Freudenthal, 1983) and (3) the function as a mathematical object that has been formalized (Gravemeijer, 1999). Simultaneously, it is important to understand and carefully plan the role of ICT for the learning process (Lapp, 1999; Adams, 2000).
Tools matter: they stand between the user and the phenomenon to be modeled, and shape student learning (Ponte, 1992). Instrumentation theory focuses on the mediating role of tools by stressing the co-emergence of tool techniques and meaning in a process of instrumental genesis (Gravemeijer & Cobb, 2006). This may help to understand the difficulties students experience when using computer tools. As a point of departure, we follow Hoyles & Noss (2003) in observing that tool characteristics do affect student learning: "The student, the teacher, and the computer all coexist in a complex cognitive system that is dynamically interacting and continuously transforming." (Hoyles & Noss, 2003). This may help to understand the difficulties students experience when using computer tools.

As a consequence, a bilateral relationship between the tool and the student arises. For instance, we inserted preliminary paper-and-pencil activities as a way to use a ready-made computer tool and explain the importance of aligning the use of tool options in the learning arrangement. The results of the initial open-ended group activities of the first teaching experiment were then used to construct the computer tool that students could use and in a sense shapes the tool, the affordances and constraints of the tool, which are defined as "the real and potential means provided by a tool to support the execution of an activity" (Engle, Smith & Hughes, 2006). The computer tool is an applet called AlgebraArrows, which allows for the construction and use of chains of operations (so-called arrow chains) as a sensible way to explore using a paper model and then translating them into a chaining model of dynamic functions. The teacher guide describes the different activities and their possible use and sequence in the classroom to be used in combination with the AlgebraArrows computer tool.

Instrumentation theory reveals the problems that may arise when starting to use computer tools and explains the importance of aligning the use of computer tool and paper-and-pencil techniques, and finally a computer lesson with applications and a closing lesson for all 155 students. A second researcher coded 55 out of 306 items from the second teaching experiment with a stronger emphasis on break-even points as a way to structure inquiry about dependency relationships through the construction and use of chains of operations (so-called arrow chains) as a way to explore using a paper model and then translating them into a chaining model of dynamic functions. The computer tool is an applet called AlgebraArrows, which allows for the construction and use of chains of operations (so-called arrow chains) as a sensible way to explore using a paper model and then translating them into a chaining model of dynamic functions. The teacher guide describes the different activities and their possible use and sequence in the classroom to be used in combination with the AlgebraArrows computer tool.

The whole class discussions about students' activities during group work, paper presentations, computer activities in pairs, and whole class discussions on the results, supported by performances of computer work (Yackel, 1996; Gravemeijer & Cobb, 2006). The whole class discussion on the results, supported by performances of computer work (Yackel, 1996; Gravemeijer & Cobb, 2006). This may help to understand the difficulties students experience when using computer tools. As a consequence, a bilateral relationship between the tool and the student arises. For instance, we inserted preliminary paper-and-pencil activities as a way to use a ready-made computer tool and explain the importance of aligning the use of tool options in the learning arrangement. The results of the initial open-ended group activities of the first teaching experiment were then used to construct the computer tool that students could use and in a sense shapes the tool, the affordances and constraints of the tool, which are defined as "the real and potential means provided by a tool to support the execution of an activity" (Engle, Smith & Hughes, 2006). The computer tool is an applet called AlgebraArrows, which allows for the construction and use of chains of operations (so-called arrow chains) as a sensible way to explore using a paper model and then translating them into a chaining model of dynamic functions. The teacher guide describes the different activities and their possible use and sequence in the classroom to be used in combination with the AlgebraArrows computer tool.

Test items in the two tests are comparable in length and difficulty and have similar scoring instructions. The whole class discussions on the results, supported by performances of computer work (Yackel, 1996; Gravemeijer & Cobb, 2006). This may help to understand the difficulties students experience when using computer tools. As a consequence, a bilateral relationship between the tool and the student arises. For instance, we inserted preliminary paper-and-pencil activities as a way to use a ready-made computer tool and explain the importance of aligning the use of tool options in the learning arrangement. The results of the initial open-ended group activities of the first teaching experiment were then used to construct the computer tool that students could use and in a sense shapes the tool, the affordances and constraints of the tool, which are defined as "the real and potential means provided by a tool to support the execution of an activity" (Engle, Smith & Hughes, 2006). The computer tool is an applet called AlgebraArrows, which allows for the construction and use of chains of operations (so-called arrow chains) as a sensible way to explore using a paper model and then translating them into a chaining model of dynamic functions. The teacher guide describes the different activities and their possible use and sequence in the classroom to be used in combination with the AlgebraArrows computer tool.

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TOOL USE AND THE DEVELOPMENT OF THE FUNCTION CONCEPT 1259

Figure 3. Written calculation chains for cellphone offers (called ‘Soms’ and ‘Vaak’)

A: Well, then you subtract 22,50 euro and divide it by 15 cent, and this results in minutes, and then you add 80, that are the free minutes which you receive.

S1: Put 10 in the input box

T: Suppose I want to know the output from many input values, what more can I use?

R: … Well, maybe 50.

[Enters 100 as input in both chains. TomSeldom (Soms) is cheaper than the other offer.]

The third lesson, the first computer lesson, started with some introductory activities and an introduction to the computer tool. In the next activity, the last one before the computer work by using a beamer. Topics of discussion were the possibility to create posters about the effectiveness of the two offers. The students’ posters that describe the two offers and more efficient notations and tools for finding break-even points. These strategies were exploited by the teacher by linking the students’ thinking and that (2) create starting points for discussing the need for determining variables, dependency relationships, and more efficient notations and tools for finding break-even points.

The advantage of the computer tool is that students can use it to construct arrow chains, a key element to represent functions. With the computer tool, they constructed chains of operations, with operations on the variables. This is quite similar to the cellphone activity. However, the way in which they proceed was different. The students’ initial technique with the applet suggested a tool which was used to create arrow chains. The arrow chain tool reflects the development from viewing calculation recipes as tools for repeated calculations. More specifically, the vignette illustrates how the arrow chain tool technique to construct chains supports this, and the chain became a tool to trace a graph and to zoom in and out. In this way, together with demonstrating the creation of arrow chains, the teacher could explain that there is a link between the dependent and independent variables, and how they use the representations in the tool to change graphs and to summarize the dependence, and how they use the representations in the tool to change graphs and to summarize the dependence.

L: Company Pieters charges start costs and an hourly rate for each hour. The company Pieters also offers include a maximum of 50 minutes free time per call. For each minute of exceeding the free time, Pieters charges 75 cent. You can call for a maximum of 60 minutes. T: How much do you have to pay if you use 30 min.?

R: … Well, maybe 50.

[The inbox and outbox are positioned in the drawing area. Labels are created according to the chain of operations is constructed and connected to the input and output boxes.

T: What were able to do in this input area?

R: … It was no box.

[Silence]

T: How can you demonstrate that? [Silence] For example if I call 10 min. What ways do I know to pay this amount?

R: … I can do the multiplication and I can do the addition.

T: I heard different ways to find out how much I have to pay, how the amount changes, how much a company offers and how much they charge.

R: … I think of two ways. One is to create a graph and the other is to calculate.

T: A company offers two different offers. Which one offers the better offer?

S1: Put 10 in the input box

S2: … It was a question about two dependency relationships. For investigating the computer tool reflects the development from viewing calculation recipes as tools for repeated calculations. Where the students’ initial technique with the applet suggested a tool which was used to create arrow chains, the arrow chain tool reflects the development from viewing calculation recipes as tools for repeated calculations. More specifically, the vignette illustrates how the arrow chain tool technique to construct chains supports this, and the chain became a tool to trace a graph and to zoom in and out. In this way, together with demonstrating the creation of arrow chains, the teacher could explain that there is a link between the dependent and independent variables, and how they use the representations in the tool to change graphs and to summarize the dependence, and how they use the representations in the tool to change graphs and to summarize the dependence.

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[Enters 100 as input in both chains. TomSeldom (Soms) is cheaper than the other offer.]

The third lesson, the first computer lesson, started with some introductory activities and an introduction to the computer tool. In the next activity, the last one before the computer work by using a beamer. Topics of discussion were the possibility to create posters about the effectiveness of the two offers. The students’ posters that describe the two offers and more efficient notations and tools for finding break-even points. These strategies were exploited by the teacher by linking the students’ thinking and that (2) create starting points for discussing the need for determining variables, dependency relationships, and more efficient notations and tools for finding break-even points.

The advantage of the computer tool is that students can use it to construct arrow chains, a key element to represent functions. With the computer tool, they constructed chains of operations, with operations on the variables. This is quite similar to the cellphone activity. However, the way in which they proceed was different. The students’ initial technique with the applet suggested a tool which was used to create arrow chains. The arrow chain tool reflects the development from viewing calculation recipes as tools for repeated calculations. More specifically, the vignette illustrates how the arrow chain tool technique to construct chains supports this, and the chain became a tool to trace a graph and to zoom in and out. In this way, together with demonstrating the creation of arrow chains, the teacher could explain that there is a link between the dependent and independent variables, and how they use the representations in the tool to change graphs and to summarize the dependence, and how they use the representations in the tool to change graphs and to summarize the dependence.

L: And the other is TweeHoog …

T: What was the company that charged the most?

R: … TomSeldom (Soms) was the company that charged the most.

T: How much do you have to pay if you use 30 min.?

S1: Put 10 in the input box

S2: … It was a question about two dependency relationships. For investigating the computer tool reflects the development from viewing calculation recipes as tools for repeated calculations. Where the students’ initial technique with the applet suggested a tool which was used to create arrow chains, the arrow chain tool reflects the development from viewing calculation recipes as tools for repeated calculations. More specifically, the vignette illustrates how the arrow chain tool technique to construct chains supports this, and the chain became a tool to trace a graph and to zoom in and out. In this way, together with demonstrating the creation of arrow chains, the teacher could explain that there is a link between the dependent and independent variables, and how they use the representations in the tool to change graphs and to summarize the dependence, and how they use the representations in the tool to change graphs and to summarize the dependence.
procedural calculation understanding to a structural correspondence and covariation understanding of functions. Although the arrangement had the different representations needed for this particular work. The students' reasoning. Students could be close to a good answer and then delete everything as a result of a sudden doubt. Final screenshots of this learning arrangement and the computer tool.

The results cannot be generalized beyond this particular program. Further research is needed for a full understanding of students' conceptual development in this particular setting.


In the eighties, we distinguish three factors that made the implementation of problem solving only a limited success in developed, and to engage in problem solving activities:

- Problem solving lends itself excellently to the use of mathematics to solve real world problems. It itself (the product). In its initial years, modelling and 'pure' and abstract mathematics, and also more on the mathematical concept building (Gravemeijer and Doorman 1987) showed examples of real world problem solving, and it was introduced as a new curriculum subject in pre-university education (vwo) in The Netherlands in 1989. Since then, it has to be truly authentic in order to let the highly experienced as a real problem by the students. In fact, the context may even be rather unrealistic or within mathematics, if concept development requires it. However, the contextual problem must be context-specific solution strategies, and are used to support learning in the mathematics community. Journal of Mathematics Teacher Education, 5, 205–233.

- Mathematics A was meant for students who appreciated the process of mathematization take full bloom. In mathematics A, the emphasis lay more on applications and problem solving, and problem solving

- In primary education it still is not. For upper secondary education were not affected by this: no...
Dutch mathematics education. This is because many teachers and students believe that mathematics is a purely abstract subject, and they often avoid applying it to real-world situations. Furthermore, the Dutch national educational system is designed to prepare students for the workplace, not for creativity and problem-solving. This can lead to a lack of problem-solving skills in Dutch students, which is a major concern in today's world.

In order to solve these larger problem-solving tasks, students must understand and interpret the available information, and then use this information to construct and evaluate possible solutions. This requires a strong foundation in both abstract and applied mathematics.

For all of us who thought that we as mathematics developers and researchers did our job quite well and the Dutch students are now doing wonders with this mathematical literacy, it is important to remember that much is still needed. We need to continue to improve our teaching methods and provide our students with the tools they need to succeed in the future.
solving on a serious level. If these skills are not needed for change and hope that the start that is given for this in the 

do not often come across problems that require profound 

good students can find it difficult to persevere because they 

problem did not try anything on paper either, is also significant. Except that the trend to not even start could result 

central, written, individual, final examination. The design of 

TAL learning-teaching trajectory for calculation with 

very long about the problems they normally encounter.

the majority of the children who could not solve this 

closed: 'poor' final exams bring about 'poor' education. 

are exemplary to problem solving, an example of the first is 

designing teacher and student proof activities, and the time 

problem solving as a result of examination demands, 

like the one for mathematics A tends to standardize problem-solving tasks into routine assignments. The national 

6 Mathematics A-lympiad: an experimental garden 

non-routine problem solving.

been much support from textbooks series and the Cito test 

complicating factor here is that up to now there has not 

activity can introduce more problem solving to the Dutch 

primary school curriculum.

6.1.6 Some revealing results 

students found the right answer mentally. Although this 

about 1,500 teams. This means that every year about 

was exceptional in mathematics education to call on skills 

place in a large number of schools in The Netherlands.

important initiatives for enhancing problem solving 

by their teachers on the basis of their mathematics score. In 

10 year olds) took the test. The students belonged to the 

likely explain why the differences between the students 

the students have not learned to use 

many students did not write anything down, many students 

In reviewing all the students' responses and the experiences from the interviews, three tendencies were found: 

their thought process.

include the need for designing problem solving activities. An exception is the textbook series 'Wiskundelijn' (Bos et al. 1990), 

It seems obvious that problem solving should be an inherent 

part of the mathematics A curriculum. In the educational 

order thinking goals, problem solving and modelling. This 

discussed in more detail.

6.1.5 The question of the problem-solving activity 

for identifying problem-solving skills in primary education in the recently established Gauss-Interactions Day. On this day, that is prepared 

(by: Dr. E. A. Bos). 

In the case of this problem, one could think of listing the 

most cases this was the students' score on the Cito Student 

about 1,500 teams. This means that every year about 

has seen a growing number of 

participating schools in the first 10–12 years, though that 

location. The competition has seen a growing number of 

participating schools in the first 10–12 years, though that 

important initiatives for enhancing problem solving in Dutch primary education, we 

the areas of others concerning problem solving in Dutch primary education, we 

Dr. E. A. Bos). 

mind of the students, one could say that this was 'spending time'. 

As is shown in Table 1, 74 of the 113 children who did not find the right 

is that 74 of the 113 children who did not find the right 

of students 

Wrong answer 74 39 113 

Table 1 The results from high achievers in grade 4 

Fig. 2 Problem: Find the number 

If you divide it by 7, there is no remainder. 

It is smaller than 100. 

The analysis of the student responses in the test booklets 

undertakings are made with respect to the introduction of systematic solutions. We therefore consider it to be important to 

not encounter this kind of problem that often in textbook 

series and tests in The Netherlands. The 15 problems were 

will perform problem-solving tasks that have been developed for the World Class Tests. In total, 15 problems were 

put in a test booklet with every problem presented on a
In the second part of the assignment the teams were asked to determine which species had to be protected and which could be allowed to disappear. Chance of survival' indeed seems to be a number, but it is not an easy number to find. Some participating teams commented on the task in a way that it was not possible that one species did obtain an extreme score. In other words: the system had to give more importance to the species that have died out whose existence is unknown to the students. Then a minimum distance means a close relationship between the two species and a maximum distance means that the two species are not related at all. This can be seen as a criticism of the assignment or of the process of allocating values. Furthermore, there was lack of clarity with the terms. This type of mathematics is precisely the mathematics we are taught in school, but it is more a criticism of the assignment than of the students' work. The search for an acceptable value scale by the teams was important arguments for prioritizing the preservation of different species. This value scale was to be used to bring the values closer together. None of the teams were asked to devise a function themselves that produces this ranking, but almost every team tried to do so. Using this information the teams had to decide what criteria for determining which plants and animals are most important to save, if the goal is to keep species diversity in the long run.

Teams that used the genealogical tree presented as an example in the assignment (Fig. 5), it is specified for two combinations of species contained 'fewer genes'. It was also believed that 'as many genes as possible' would be preserved. Species that were further away from this original species would be a threat to the ecological equilibrium than by equal quantities. And in equilibrium: the ecological equilibrium than by equal quantities. However, nature is better served by species that are closely related, it is less serious if one of them dies out, than by elephants.'

A better factor for determining the level of diversity is how much the plants in the photos varied from each other. The second approach examines how the different species are mutually related. This can be done by counting the number of different combinations of species that occurred in each photo with a photo ratio of: 4:0:2:1:3:25:21:25 had the greatest diversity. When the photo with the greatest number of plants was chosen, the diversity was greatest when all plants occurred together with the genealogical tree in the same figure. The third approach concede that these percentages were based on the average numbers. Teams that used this method the diversity was greatest when all plants occurred together with the genealogical tree presented as an example in the assignment (Fig. 5), it is specified for two combinations of species contained 'fewer genes'. It was also believed that 'as many genes as possible' would be preserved. Species that were further away from this original species would be a threat to the ecological equilibrium than by equal quantities. And in equilibrium: the ecological equilibrium than by equal quantities. However, nature is better served by species that are closely related, it is less serious if one of them dies out, than by elephants.'

The standard deviation of these numbers is 16.49. If the diversity of the other photos is calculated in this way, you get the following standard deviations:

- photo 1: 16.49
- photo 2: 9.49
- photo 3: 8.00
- photo 4: 14.14

When this species is left out, a new tree can be made and the final result will not be far from the average numbers. This method the diversity was greatest when all plants occurred together with the genealogical tree in the same figure. The third approach concede that these percentages were based on the average numbers. Teams that used this method the diversity was greatest when all plants occurred together with the genealogical tree presented as an example in the assignment (Fig. 5), it is specified for two combinations of species contained 'fewer genes'. It was also believed that 'as many genes as possible' would be preserved. Species that were further away from this original species would be a threat to the ecological equilibrium than by equal quantities. And in equilibrium: the ecological equilibrium than by equal quantities. However, nature is better served by species that are closely related, it is less serious if one of them dies out, than by elephants.'

A number of photos of different combinations of plants were used in this approach. The standard deviation of these numbers is 16.49. If the diversity of the other photos is calculated in this way, you get the following standard deviations:

- photo 1: 16.49
- photo 2: 9.49
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As a final perspective on problem solving, we consider the remarkable changes:

1. The experiences with the B-day show that problem solving has been restructured. A part of this reform is the growing importance of mastering routine operations. This means that students are deprived of the possibility of obtaining 'expert knowledge'. The Mathematics A-lympiad and B-day is very convenient mathematical applications in exact sciences as well.

2. Due to the use of technological tools, the repertoire of mathematical practices that would not be possible to implement in the past—such as estimating numerical values, practicing skill in the past—will hardly matter. On the other hand, skills such as estimating numerical values, solving realistic problems, formulating and solving problems, working in teams, etc. are new mathematical practices that would not be possible to implement in the past. This is also true for working in teams, etc. The potential of the technological tool evidently offers the opportunity to follow the graph point by point. The user can see how a graph (or a curve or a group of points) is moving, how the distance between two points varies, and how the orientation, the choice of an appropriate coordinate system and the choice of the unit of measurement, change. The focus then was on the development of the students' mathematical understanding. This can be generalized and the situation can be expressed in terms of the educational practice, but by its structure does not allow for real problem solving activities. A second obstacle is the fact that drawing conclusions from investigative activities are deprived of the possibility of obtaining 'expert knowledge'. The Mathematics A-lympiad and B-day is very convenient mathematical applications in exact sciences as well.

3. The main focus is on the development of the students' mathematical understanding. This can be generalized and the situation can be expressed in terms of the educational practice, but by its structure does not allow for real problem solving activities. A second obstacle is the fact that drawing conclusions from investigative activities are deprived of the possibility of obtaining 'expert knowledge'. The Mathematics A-lympiad and B-day is very convenient mathematical applications in exact sciences as well.

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Participant 1: You see? Like, I said, some of the learners they don't know, when you're playing football or any other sports, Maths is applicable everywhere.

Interviewer: Definitely, it is more important to relate it to more real-life situations.

Participant 1: The application of calculus.

Interviewer: Good, ja, interest and stuff like that.

Interviewer: And they tell that to the children?

Participant 1: Ja, an account. So it is difficult to relate this to somebody who doesn't know about the situation.

Interviewer: An account.

Participant 1: And also financial Maths, because we are working with money everyday.

Interviewer: Good, ja.

Interviewer: Ja, which sections of work do you think will be easiest to link to real-life situations?

Participant 1: It's difficult to relate.

Interviewer: Okay, but others it's difficult to relate?

Interviewer: Okay, do you have the time to do it? Or is it not really realistic to expect one to relate the work to real-life?

Participant 1: Ja, practice.

Participant 1: Ja, but it takes time for one to master the curriculum.

Interviewer: Ja.

Participant 1: But I was teaching geometry before. Uhm, it's financial Maths, probability and what is it .... Geometry.

Interviewer: Hmm.

Participant 1: So if you're talking about the money in the bank, they have never been to a bank.

Interviewer: That you start with the basics and then ...

Participant 1: Ja, any form of technology.

Participant 1: Ja, because there is a huge gap between tech and curriculum.

Interviewer: Good, now you have been exposed to the 3 levels.

Interviewer: So, your facilities and your resources are a problem?

Participant 1: Yes.

Participant 1: Yes, it's a problem.

Interviewer: I see, ja.

Interviewer: So, your facilities and your resources are a problem?
Interviewer: Okay, thank you Mr Sindwa. Thank you for the valuable information.

Participant 1: Normally I’m using the email of the school.

Interviewer: So, email can work for you?

Participant 1: I just wanted to buy myself one.

Participant 1: I’ve got a laptop, but as I’m saying we only have one projector.

Interviewer: Laptop, okay.

Participant 1: Laptop.

Participant 1: Maybe they are ashamed to ask questions, and here they hear it for the second time, so somebody is going to ask questions about that, or maybe get clarity about that.

Interviewer: How do you feel about using the interactive whiteboard to discuss with me and with other colleagues issues ... your learners? How to deal with problem areas? Would you be willing to have a discussion on an interactive whiteboard?

Participant 1: I don’t know.

Interviewer: Could be.

Interviewer: Now, you've now noticed the learners sitting in the class at the interactive whiteboard sessions. What did you pick up there? You mention some of it in the classroom just now.

Participant 1: At the back.

Interviewer: Because there is not somebody standing in front, it’s like watching TV almost? And the show just carries on?

Participant 1: Ja.

Participant 1: And maybe do they get bored? Some of them?

Participant 1: I always go and sit there doing my work. At least I can see there are two or three learners who are listening very attentively and follow what is going on and they ask questions. Some of them don't even bother to ask questions.

Participant 1: Ja.

Interviewer: That's it, ja. Okay, so that question about how do you feel about using Facebook to discuss issues of making ... learners? Rather than really social media? Then it's more like work on Facebook, you would be interested in using that?

Participant 1: I will be interested.

Interviewer: If one were to create a work group on Facebook, also to help with the Maths, do you think you would be interested? Or not actually?

Participant 1: I think there would be more interest of learners.

Interviewer: How do you feel about using interactive whiteboards to discuss with me and with other colleagues issues that are in a project such as the one we’re working on? How could it be useful?

Interviewer: That’s it, ja. Okay, so that question about how do you feel about using Facebook to discuss issues of making ... learners? Rather than really social media? Then it's more like work on Facebook, you would be interested in using that?
Hans Freudenthal

Why to Teach Mathematics So as to be Useful

In educational philosophies of the past, mathematics often had been taught so as to be useful. The disadvantage of useful mathematics is that it is not mathematics at all. The opposite attitude would be to teach useful mathematics. It has not been tried so far, though it is not impossible. The great virtue of mathematics is its flexibility. It takes some time, but finally everybody learns that in all these and a hundred other situations the same arithmetical operation applies. It takes some time, but finally everybody learns that the mathematics he learns is not only useful, but also indispensable for the understanding and application of the physical world but also of the social world. 

The use of mathematics, though not inherently part of the study of natural sciences, is no less a part of the study of social sciences. In educational philosophies of the past, mathematics has often been taught so as to be used for purposes other than those of natural sciences. In educational philosophies of the future, mathematics has to be used for those purposes other than those of natural sciences. 

At the present stage of development, the use of mathematics is limited by a few restrictions. First of all, mathematics is not yet sufficiently taught. Mathematics is learned in school, not taught. Mathematics is not learned in school, it is taught. Mathematics is not learned in school, it is taught. Mathematics is not learned in school, it is taught. Mathematics is learned in school, it is taught. Mathematics is not learned in school, it is taught. Mathematics is taught in school, it is taught. Mathematics is taught in school, it is taught.

By contrast, the abstract theory of fractions has to be applied. If afterwards the abstract theory of fractions has to be applied, in a concrete context is no more than a ceremony which is hurried through. The counterexample is fractions. In its traditional teaching, mathematics is divided into two parts: pure and applied. Pure mathematics has only a few applications, and applied mathematics has only a few applications. The counterexample is fractions. The counterexample is fractions. The counterexample is fractions.

If there are ten students in the room and three are girls, how many are boys? How many are girls? How many are boys? If I have got ten marbles and I give three away, how many are left? How many marbles are left? How many marbles are left? How many marbles are left? If I have got ten marbles and I give three away, how many are left? How many are left? How many are left? How many marbles are left? If I have got ten marbles and I give three away, how many are left? How many marbles are left? If I have got ten marbles and I give three away, how many are left? How many marbles are left? If I have got ten marbles and I give three away, how many are left?

Since mathematics has proved indispensible for the understanding and application of the physical world but also of the social world, it is a fact that most of this learning process, though made in a more or less artificial environment, can and must be used for the understanding and application of the social world.

The huge majority of students are not able to apply their theoretical knowledge of such a generality, from other knowledge of such a generality. Therefore, the education of the huge majority of students is wasted on individuals who are not able to avail themselves of this flexibility. Mathematics is taught so as to be useful, after we had agreed that it is mathematics.

This is a remarkable fact that people are able to apply what they have learned and afterwards to show how to teach mathematics so as to be useful, after we had agreed that it is mathematics.

If I am ten years old now, how old was I three years ago? If I am ten years old now, how old was I three years ago? If I am ten years old now, how old was I three years ago? If I am ten years old now, how old was I three years ago? If I am ten years old now, how old was I three years ago? If I am ten years old now, how old was I three years ago? If I am ten years old now, how old was I three years ago?

Mathematics is distinguished from other subjects by its greatest virtue, its flexibility. It can be used for a richer variety of situations than classroom-oriented. Very little, if anything, can be performed by machines, we need no technological control not only of the physical world but also of the social world.

New mathematics has been met with criticism. People who apply mathematics to other subjects say that the new mathematics is not mathematics at all. The huge majority of students are not able to apply their theoretical knowledge of such a generality, from other knowledge of such a generality. Therefore, the education of the huge majority of students is wasted on individuals who are not able to avail themselves of this flexibility. Mathematics is taught so as to be useful, after we had agreed that it is mathematics.

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If B is between A and C, B is at a distance of 7 miles from A, and C is at a distance of 9 miles from A. If B is between A and C, B is at a distance of 7 miles from A, and C is at a distance of 9 miles from A. If B is between A and C, B is at a distance of 7 miles from A, and C is at a distance of 9 miles from A.

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From a constructivist perspective, we have no way of knowing whether a concept matches an objective reality. Our concern is whether it works (fits with our experiences). Constructivism derives from a philosophical position that we as human beings always construct our own realities. We do not receive data from the environment and then organize it in a cognitive structure. Instead, our experiences, our observations, are always organized in the light of our previous experiences. This means that our experiences of the world are always constructed and not a direct representation of reality. The process of constructing our understanding of the world is not a passive one, but a process of actively engaging with the world and constructing our own knowledge. This means that our understanding of the world is always provisional and subject to change as we gather new information and have new experiences. The process of constructing our understanding of the world is not just a cognitive process, but a social process as well. Our understanding of the world is always constructed in a community of learners, and our understanding is influenced by the beliefs and values of that community. This means that our understanding of the world is always subject to change as we interact with others and as our community of learners changes.

One of the most important implications of constructivism is that learning is always a social process. Our understanding of the world is always constructed in a community of learners, and our understanding is influenced by the beliefs and values of that community. This means that our understanding of the world is always subject to change as we interact with others and as our community of learners changes. The role of the teacher in this process is not to simply deliver information, but to facilitate the construction of knowledge in the learner. The teacher must provide opportunities for the learner to construct their own understanding of the world, and to engage in social interaction with others to refine and extend their understanding.

Despite these important implications, constructivism is not a one-size-fits-all theory of learning. It is not a theory that can be applied to all situations. Constructivism is a theory of learning that is best suited to situations where the learner has some prior knowledge and can actively engage with the material. It is not a theory that can be applied to situations where the learner has no prior knowledge or where the learner is simply passively receiving information. Constructivism is a theory of learning that is best suited to situations where the learner can actively engage with the material and construct their own understanding of the world. It is not a theory that can be applied to situations where the learner is simply passively receiving information.

Constructivism is not a theory of learning that is best suited to situations where the learner has no prior knowledge or where the learner is simply passively receiving information. It is a theory of learning that is best suited to situations where the learner can actively engage with the material and construct their own understanding of the world. It is not a theory that can be applied to situations where the learner is simply passively receiving information.
The rectangles problem. As the instructor, r chose to begin the exploration of multiplicative relationships in the evaluation of area of rectangles. My purpose was to consider whether a claim could be defended that the observed phenomenon would occur and with greater frequency in the classroom. It was only recently that empirically based models for studying mathematics learning in classrooms had been articulated (cf. Wood, Cobb, Yackel, & Dillon, 1990a). Earlier empirical work, which derived from, and contributed to, epistemological theory, focused on the cognitive development of individual learners (cf. Steffe, 1988). The need for pedagogical frameworks is sometimes obscured by the tendency to view research as being either qualitative or quantitative, with little attention given to their interdependence. Much of the teacher's responsibilities involve planning. However, the planning process is frequently undertaken in an ad hoc and haphazard manner. This research was intended to contribute to teacher planning. Brousseau (1987) asserts that part of the role of the teacher is to provide a context for the study of that content. "This section begins with some background on the teaching experiment and its purpose."

The teaching experiment was created to learn about students' developing conceptions of number and arithmetic operations. The project studied the prospective teachers in the context of an experimental teacher preparation program designed to increase their knowledge of mathematics learning and to foster their development of views of mathematics, teaching, and learning. Although the prospective teachers were enrolled in a 5-week pre-student-teaching practicum, the data collection proceeded throughout an entire mathematics course, a course on teaching mathematics, and explored prospective teachers' conceptions of number and arithmetic operations. The teaching experiment was part of the Construction of Elementary Mathematics Knowledge Project, a multiyear research project funded by the National Science Foundation (Grant #DUE-8954781). The project studied the prospective teachers in the context of an experimental teacher preparation program designed to increase their knowledge of mathematics learning and teaching. The teaching experiment was created to learn about students' developing conceptions of number and arithmetic operations. The project studied the prospective teachers in the context of an experimental teacher preparation program designed to increase their knowledge of mathematics learning and teaching.
I had engaged them in a problem-solving activity using a hands-on activity and Situation I. What instructional situation might afford other students the opportunity to engage in a meaningful activity with the same goal? Karen has made some progress in justifying the use of multiplication. However, their competence in providing justification would grow as they engaged in discussions of the relationships between the length and the width and multiplying those quantities, and the goal of this activity would be to help students understand the concept of area. The stick problem, Two people work together to measure the size of a rectangular area, is a modification of the original problem turning the rectangle problem into a problem with a known quantity of units. As a result of Rectangles Problem I, and because the measurement was still being represented with linear units, students were working (area) was not well understood by many of the students. They were working on the problem without knowing how to determine the size of the rectangular area. Eventually, they would still need to sort out the problem involving the rectangular area and its linear units. Having constructed hypotheses of the students' thinking, I still needed to generate an appropriate instructional situation that would still need to sort out the problem involving the rectangular area and its linear units. The blob problem: How can you find the area of this figure? I had always posed the problem (of turning the rectangle) within the whole-class discussion, and there had always been some students who explained about the square and that method of counting the units. Perhaps Problem 2 shifted the discussion from my problem-justifying strategies to students' strategies. Initially, they were confident in their view that the number generated by this method was nonsense because it resulted in overlapping rectangles. I tried in different ways to promote disequilibrium so the students would reconsider the issue. Toward this end, I would try to challenge their assumptions by asking questions on this connection. The student who had made the original suggestion was the first to suggest finding the area by adding the number of squares from both the row and the column. They were confident in their view that the number generated by this method was nonsense because it resulted in overlapping rectangles. I tried in different ways to promote disequilibrium so the students would reconsider the issue. Toward this end, I would try to challenge their assumptions by asking questions on this connection.


The hypothesis of a teacher's thinking is the central piece of the model that is diagrammed in the hypothetical learning trajectory. It is meant to capture the importance of having a goal and rationale for teaching decisions and the hypothetical nature of such thinking. Note that although often similar, paths. This assumes that an individual's learning has some regularity to it (cf. Steffe, et al., 1983, p. 118), that the classroom community constrains...
recognize that constructivism does not tell us how to teach that will motivate increased work in this area. Such an approach does not deal with a key question: If a group of students do not hoping that at least one student will be able to explain it to the others (Simon, 1991 ). By what means can a teacher help students to develop new, more powerful reform in mathematics teaching. Research on how students develop particular mathematical knowledge (cf. Steffe, et al., 1983, see pp. 118 & 135; Thompson, 1994)

The Mathematics Teaching Cycle portrays a view of teacher decision making with Steffe's comments seem to underscore the cyclical nature of this teaching process. The former involves creation of instructional goals and hypotheses about how students might move towards those goals as a result of their collective engagement in which a teacher can make decisions as to the content, design, and sequence of mathematical tasks. The model emphasizes the important interplay between the teacher's knowledge of mathematical activities and representation, and students' knowledge and understanding of the particular content. However, constructivism also poses a challenge to the mathematics education of particular representations and conceptual difficulties for my current students and represent a set's readiness for them to experience. Constructivism encourages the development of an environment that allows students to construct their own meanings in the classroom. Several actual learning and teaching episodes. (Steffe, 1991, p. 192) The Mathematics Teaching Cycle portrays a view of teacher decision making with Steffe's comments seem to underscore the cyclical nature of this teaching process. The former involves creation of instructional goals and hypotheses about how students might move towards those goals as a result of their collective engagement in which a teacher can make decisions as to the content, design, and sequence of mathematical tasks. The model emphasizes the important interplay between the teacher's knowledge of mathematical activities and representation, and students' knowledge and understanding of the particular content. However, constructivism also poses a challenge to the mathematics education of particular representations and conceptual difficulties for my current students and represent a set's readiness for them to experience. Constructivism encourages the development of an environment that allows students to construct their own meanings in the classroom. Several actual learning and teaching episodes. (Steffe, 1991, p. 192)


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Table 1: Buses.

<table>
<thead>
<tr>
<th>Width</th>
<th>Length</th>
<th>Height</th>
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<tbody>
<tr>
<td>3.60</td>
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<tr>
<td>7.36</td>
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<td>2.59</td>
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Fig. 3. Buses.

In conclusion the unravelling of the matter of the 14 square kilometres. It was added that the newspapers were given the area in square yards: 12820 square yards. The conversion of yards to square meters: 12820 x 0.9 = 11538. It was concluded that the newspapers had made an error, because the real area should have been 14020 square meters. More specifically, the newspapers had provided the area in square yards, whereas the real area should have been given in square meters. The newspapers should have converted the area from square yards to square meters, and this was not done.

The argument was supported by Freudenthal: 

"It was recognized by Freudenthal:"

"...to be 'vertically' mathematised') and too little on model contexts ('to be 'horizontally' mathematised') and too little on model contexts ('to be 'horizontally' mathematised') and too little on model contexts ('to be 'horizontally' mathematised')."

The model-type contexts on the other hand have primarily a vertical mathematical value for mathematising and for acquiring a mathematical altitude may be enormous in comparison. (Freudenthal, 1991).

The error of the 14 square kilometres is small, and the most important thing that was learned is perhaps, that when you multiply by 0.9 or by 0.8 (or divide), you must agree to the figure of some 10,000 square meters (0.8 x 12820).

The correct area is given - 12,820 square yards. We take another look at the painting to the road with trees showing at the top of the photo (Figure 2). Then there is also the computational argument in answering the first question about the density of the plants in the painting: 250,000 plants on 14 square kilometres. When converted does 12,820 square yards correspond with somewhere close to 14,000 square meters or 14,000 square meters? Although the Wiskobas program does devote much attention to the horizontal development in the period 1970-1990. In each instance there will be a short introduction of Vincent van Gogh's 'Sunflowers'. With the assistance of twenty

moments of discussion are introduced when making an inventory of the various stages of the growth of the painting to the road with trees showing at the top of the photo (Figure 2). Then there is also the computational argument in answering the first question 'How do you explain the error of the 14 square kilometres?'

The conclusion that Wiskobas spent too much energy in those days on the design of the painting to the road with trees showing at the top of the photo (Figure 2). Then there is also the computational argument in answering the first question 'How do you explain the error of the 14 square kilometres?'

...and too little on model contexts ('to be 'horizontally' mathematised') and too little on model contexts ('to be 'horizontally' mathematised')."
ground by using the student. But it also applies in general, the impression of problems of current, social and educational relevance and the decisive nature of the results obtained. How does Freudenthal's didactic model contribute to the development of the student's learning abilities? What does it mean to construct a model of learning and teaching in mathematics? What are the implications of Freudenthal's ideas for the design of educational materials and teaching strategies? How do Freudenthal's ideas shape the current landscape of mathematics education?

Hermeneutic Unit: Systematic literature review relating to the use of IC...
As co-founders. The idea to approach innovation of mathematics education on Wiskobas became a department of the IOWO. Wiskobas pioneers Wijdeveld and research comprises much more therefore than empiric testing, but rather all sorts of development, research and teaching (also see Gravemeijer, 1989). Developmental research denotes a comprehensive program that is directed at development of textbooks, tests and curricula that at the end of the eighties the development of textbooks, tests and curricula that lays the foundation for this didactical realism and determined the development of concrete education for various main learning strands, but more indirectly than Freudenthal's authority, status and influence that this integral approach did indeed distinguish itself there from natural sciences. Elementary mathematics was in-...
Hermeneutic Unit: Systematic literature review relating to the use if IC...
And finally the old question: why does a mirror interchange right and left? Why can a table with four legs wobble, and what is the difference with a table under rigid motions? What is the difference between a right and a left screw and why are not they equivalent? How can you measure the inclination of a line and a plane, or of two planes? What is larger, the superficies of a sphere cap, or that of the cylinder around it? How does the liquid level in some vessel change if a certain quantity of liquid is added? How does a kaleidoscope work? What does a cube look like if viewed along a spatial diagonal? The previous example shows a remarkable structure of the learning process. The van Hiele levels of the learning process are often characterized by a logical feature: the activity on one level is subjected to analysis on the next, further up a ladder. It sounds old fashioned to claim that geometry should be related to physical objects. There existed other branches, too, algebra, trigonometry, calculus, which, not having anything to do with the world, could be taught according to a deductive system. Most mathematicians are prone to their own role in the learning process. For this reason I may dismiss the question whether people learn better by doing hands-on experiments or by watching somebody doing it or by reading about it. For doing hands-on experiments, for watching one's own hands, for reading about it, a child arrives at the same result in the same time. Therefore, I doubt the experiment. It is not the same thing to learn inductively or inductively. You know that things have to be done inductively. It is the same to learn deductively or deductively. You know that things have to be done deductively. You cannot mix the two. That would be formulating the axiomatic system to derive a series of theorems from it. You have to learn deductively, and this is what the student, and this is what he teaches. Modern didacticians would require that the student reinvent himself the subject matter. This is a modern reenforcement of the old furnished what they consider as true information. If this were the point, they would even be right. The only answer they should be given is that learning is a continuous, never-ending process. From Comenius onwards learning has been becoming more and more an active building up the subject than by passive reception of a ready made material. The instruction we provide should offer the youth as ready made material. The instruction we provide should offer the youth as ready made material. Not enough information, or wrong information, or biased information, or contaminated by elements which are foreign to deductivity. If for instance, Tatiana Ehrenfest knew mathematical axiomatics and cultivated space as a field to be organized by mathematics. We are mathematicians, we are not physicists. That means that we know everything. But our students do not know what we know. That is the measure of their ignorance: what they don't know and don't know they can learn. I am not sure how far this is true. Let us take the example of teaching Pharaoh's axioms are not used anymore, so better not start with them. That is it is clear. That is a simple problem. There are other branches, too, calculus, trigonometry, logarithms. You can teach them inductively, you can teach them deductively. It is a simple question of choice. But that is not the same as teaching a subject, that is a complex question, that is what we call pedagogy. Now, this is a complex question. It is the socratic lesson. In a thought experiment the student, and this is what he teaches. All use subject to http://about.jstor.org/terms 418 HANS FREUDENTHAL
Hans Freudenthal

Hermeneutic Unit: Systematic literature review relating to the use if IC...

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thought not often and behind
more than an estimation of the quantity of practical use. It is not only that one
major problem, the other being how to escape the bad that we have to find
reality, which is the chief problem of our time. Of course there is a way to do
experiments to learn. It is not the same as to do experiments in the laboratory,
though with strong hands, can be a leading influence in some scientific
research. Experiments with a factor in a certain situation are not the same
as experiments with a factor in another situation.

There are many ways of organizing the child's exploration of space. I quote
a very rough sketch of one of them. In the plane, there is a tendency to
be interested in the properties of shapes, to see the shapes as indivisible
units. In space, on the contrary, it is natural to see shapes as collections
of parts. In the plane, there is a tendency to find symmetry in pairs, in
space, in triplets. In the plane, there is a tendency to look for simplicity
in the plane, and in space, in complexity. In the plane, there is a tendency
to look for regularity, in space, in irregularity. In the plane, there is a
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subject matter, and what is organization, to teach them conceptualizing, and solutions, they ask for solutions without trying. Good geometry instruction was, but today the authors learned how to make more successful geometrical axiomatics prevent the student from learning organizing a subject matter on any level.

Subject matter to get the axiomatic system, cutting the bonds with the organization of a subject matter. Everybody knows how long it lasts to have an average student view a proof as a whole. It lasts still longer to have a student who has reached this level, he is pressed upon the next, the global organization. If didactically viewed, axiomatics and traditional deductivity are much more piece of indigestible mathematics.

I already explained how in introductory geometry the student can learn to stick to this one during a course of many years. All below this level, which is the local organization of a subject matter. Everybody knows how long it lasts to have an average student view a proof as a whole. It lasts still longer to have a student who has reached this level, he is pressed upon the next, the global organization. If didactically viewed, axiomatics and traditional deductivity are much more piece of indigestible mathematics.

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Often the objection is raised: Traditional deductive geometry is also deductive. But what is the difference? Traditional deductive geometry is a business of grown up mathematicians rather than of learners, or he knows from his own axiomatizing activity or a thought experiment, he never reasons within an axiomatic system, which would be much too complicated.

It is not because of its complexity that I should such an axiomatic system. The axioms of the system are not presupposed by any kind of experience. They are not presupposed by any know about the matter. They are not presupposed by any kind of reasoning which is not already presupposed by the system.

The axioms of an axiomatic system are not intended to be the result of an experience. They are not intended to be the result of knowing anything. They are not intended to be the result of reasoning which is not already presupposed by the system.

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Another benefice of axiomatics is cutting ontological bonds. In the usual (In this proposal the elliptic geometry could not possibly be replaced by matizing geometry by arguments of rigor, one has to show a context in which order, angles, and so on. I have already rejected geometric axiomatics as an context of such an attempt?

In axiomatizing) as a subject to be analyzed. What would be the educational producction to Geometry is a marvellous demonstration of this attitude. The

duction to Geometry is a marvellous demonstration of this attitude. The

reality can be cut; by anontologization it becomes a self contained field.

the principles as the first reason and on God as the first cause. But does it

the hyperbolic one. The model of the hyperbolic plane is artificial and hardly

simpler axiomatic systems though it shows special aspects and charming

OTHER VIRTUES OF AXIOMATICS

OTHER VIRTUES OF AXIOMATICS

the murder. It is questions "why? asking for a reason or for a cause. And

science, indeed, is, at a certain moment, to stop asking why. To repair the

of teachers?

at an early stag e. At a more advanced

I even doubt whether a proof of such an obvious fact as the locus property

it. It is an important step to learn that "three lines pass through the same

have also in common that no answer is definitive. You can continue

of field quantization.

transitive?", "why does the current activate the electromagnet?", and so on.

of the bisector can be recommended at an early stag e. At a more advanced

example in geometry for what I have called, local organization. It can be

Finally it may be mentioned that the different tools at the disposal of

questions about the properties of a game only if they are appropriate questions,

by such concepts as inversion, necessary and sufficient, if and

any textbooks have been going to teach transformations, rather than being

Why is it sometimes more difficult to work with symmetries than with
group of transformations, whereas they are easily worked with symmetries

There are, however, more reasons, why to start with symmetries. They are

There are, however, more reasons, why to start with symmetries. They are

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expressively looser methods grading of testpapers becomes more problematic. “We

were firmly ruled by a common opinion. Teachers complain that with deduc-

tion is not one devil menacing geometry as I suggested in the title of my paper.

There are two. The escape that is left, is the deep sea. It is a safe escape if you

just like swimming.

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Expressive little is much easier to say. The free choice is much more

university selection than the traditional one. This is a new kind of

process. The change is in the very nature of the system. The system is

no longer the source of the changes. It is the changes that are

The way teachers express them is two different ways: absorbing geometry in a system of

more reliable provided they are dull enough.

Traditional geometry was difficult to teach, but its level of rigor

mentally impossible. Here we are at the last stage of the world, and

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There are two. The escape that is left, is the deep sea. It is a safe escape if you

just like swimming.
As a useful tool, mathematics has conquered a rich variety of fast expanding areas of science and society, and as a tool it has proved indispensable for a rapidly growing host of people, who use mathematics because they cannot do without it. It is certain that it has also been the instrument of success for the vast majority of research, and for a very large number of important technical inventions. Mathematics has been an important tool for the scientist, and we have seen that it is essentially used for the solution of problems and for the translation of theory into practice.

Voyager 2 arrived one second late at its meeting with Neptune -- after having given up the duty of the mission. It is a pity that this is not the case, but in any case we are much more interested in the mission of the spacecraft than in the meeting with Neptune. The spacecraft is much more important than the meeting with Neptune, and this is also true for mathematics. Mathematics is much more important than the meeting with Neptune, and this is also true for mathematics. Mathematics is much more important than the meeting with Neptune, and this is also true for mathematics.

But what about the great majority? Are we too bold in assuming that, even to the forceful motor for its own long-term development. It is an important aspect, although of less concern to us here, since our subject of mathematics education embraces a much larger group than only future professionals of whom once again as well. We are dealing with a large group of people who are not primarily interested in mathematics, who do not see themselves as future professionals in the field of mathematics.

The great majority of people who use mathematics do so because they cannot do without it. They use mathematics in order to solve problems, and they use mathematics in order to make decisions. They use mathematics in order to make decisions, and they use mathematics in order to make decisions.

The mathematical symbols and equations are used to express the relationships between the quantities in the problem. The symbols and equations are used to express the relationships between the quantities in the problem. The symbols and equations are used to express the relationships between the quantities in the problem.

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is handed to the learner, as it were, on a plate. Mathematics was more easily invented, as it was simply a question of common sense among the sciences, even preceding astronomy by more than two millennia. As Nature gets involved common sense becomes misleading: everyone knows. Let me add the remark that the common sense roots of number extend further (or longer) have been expelled. Take the following example:

My statement that researchers have paid little attention to children's first and spontaneous arithmetical activities would seem to be contradicted by the title of page 29 of the book of which I have spoken: "Les Jeux de Nombres chez l'Enfant" (1941). The contradiction, however, is only in the title, since the work itself is not at all concerned with a common sense algorithm acquired by means of common language.

I am convinced that the common sense roots of number extend further (or longer) have been expelled. Take the following example:

Suppose we are taking a trip of 215 km; how far will we have to travel on the motorway rather than in the morning and evening when it is "closer to earth"? Yet this impression will be taught the same way, at least if the learner who became a user who feels guilty, looks for errors of his own and tries to repair them. But to understand mathematics if ever they did. The other reason is the structure of mathematics itself, which, unlike any other art or science, can be mounted in rules and algorithms. It is a pity that pilfered's first and spontaneous arithmetical activities would seem to be contradicted by the title of page 29 of the book of which I have spoken: "Les Jeux de Nombres chez l'Enfant" (1941). The contradiction, however, is only in the title, since the work itself is not at all concerned with a common sense algorithm acquired by means of common language.

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make-up is characteristic of all of them. But in no other field does organising display itself in such purity, impose itself with such force and infil~te so profou?d-

...
whether this has indeed happened? In the case of whole number, shedding the it is understood) that visual images are rough representations of mental objects. Shapes (even if materialized): all are mental objects, so far: it is understood (and forth.

The triangular pyramid is a richer structure than the tetrahedron. It was named by Bhaskara, in 11th century India; he called it the 'dumb-bell'. The vertices, edges, faces have disappeared. The thing is still connected and is so in a very special manner, spherelike (and certainly not like a other -- sticking them together as it were. Tetrahedra can thus be used as building pieces can be constructed out of their parts. Something that is finished can be be extrapolated to a term that describes how these objects are handled, namely, "concept of X" seems to mean how one conceives of an object X in a certain perspective, say, by inspection, reflection, analysis, scrutiny, or whichever way to teach X. Cautious researchers now admit that concepts are preceded by experience, but it is not until we get to this way to teach X that we realize how much the teaching and learning is mental objects. I particularly like this term because it can be used to teach X without having or being a structure. Structuring is a means of organizing phenomena, physical and mathematical, and even abstract objects. Whenever we want to know something, we always refer to a number, which is an example of a structure. A structure is a system of elements and relations between them, which allows for the formation of more complex structures. Such systems are called algebraic structures. There are plenty of them with two or more elements.

This is a meaningful question for non-mathematical objects X as well, as are: "Mathematics starting and staying in reality" was the emphasis on form, reinforced by the existence of a particularly efficient language -- favours the growth of watertight membranes between mathematic and everyday life, defined by membranes with a highly selective and effective permeability, which is the amazing result of long evolution. The permeability of the membranes dividing individual realities may depend on the active or passive origin of these fragments: whether they are due to internal phenomena or external events. The line between subject X and subject Y may be the same subject viewed from different principles or contexts. It is not the same subject, but it can be seen as such by the subject's point of view. The line between subject X and subject Y may be the same subject viewed from different principles or contexts. It is not the same subject, but it can be seen as such by the subject's point of view.

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This product is linear; to every point there is associated a unique number called its coordinate. Similarly, it is a theorem of the theory of fields that to every linear structure there is a unique field, and vice versa. If the field is in a domain of real (as well as in a domain of complex numbers) is provided with a topological structure. In this sense $\mathbb{R}$ is not only larger but also richer than that of the non-negative real numbers. For instance, the solution of a first order differential equation is a function of the variables,

$$f(x) = \int \frac{1}{x} \, dx.$$  

If these integrals are taken over a closed interval, then the domain of definition is a product of a finite number of intervals. In another sense, $\mathbb{N}$, the structure of natural numbers, is richer than $\mathbb{N}$. In this sense, $\mathbb{R}$ is not only larger but also richer than that of the non-negative real numbers. For instance, the solution of a first order differential equation is a function of the variables,

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in general function as models of the general, axiomatically defined, group concept. Or euclidean, in particular three-dimensional space, may serve as a model of a rich variety of models, for instance, red/blue, circle/square/triangle, big/small, etc.

stress that in the present context I should readily include tangibly concrete models such as wind-tunnels where aeroplane models are tested and laboratory simulations of hydrodynamic theories. In other words, models that are evaluated by which are dominated by mathematical theories of too great a complexity to be

which is actually the inverse of the term we started with. As a matter of fact, in CHAPTER 1

Who is not familiar with the so-called logical blocks, 24 in number, available in the proper goal.

the preceding of poor over rich structures, even from the viewpoint of developmental psychology. What is usually called abstracting, is most often nothing but

broadening and deepening under a variety of influences, including that of mathematics, which in turn is absorbed by that changing reality.

main characteristics: mathematising. Who was the first to use this term which.

projective geometry. Although not as palpable as gypsum models, this model is large collection of such geometrical models made -- Felix Klein -- was also, if I

"mathematical model! in a context where it wrongly suggests that mathematics directly or almost directly applies to the environment. As a matter of fact, this

the present day. Even if a "rigorous" theory is available, it is almost never applied to the models of the celestial movements -- a contraption of circles, epicycles or orbits are subjected, and the ad hoc assumptions regarding jumps from one orbit to another. In this case, structuring is performed by classifying. I chose this example not be-

"mathematical model" as it is applied and the reason why this works. Counting was indeed, common

with such things as solving formulas and procedures within formalised mathematics. Nowadays the word, "mathematics," in the broad sense, comes to bear (in 3.1.3.2 Some aspects

model describing the celestial movements -- a contraption of circles, epicycles and deferents is a typical example of asinology, a falsification model. As a result, the

as the "mathematical model" -- a valuable term, but unfortunately devaluated by thoughtless use and misuse. I have castigated this practice often enough,

...as a grossly simplified model of the evolution of the cosmos.

orbits is smeared out as a fluid -- an idea typical of a simplifying model. A particularly revealing example is the cosmological model of the expanding universe. It was

still understood as a grossly simplified model of the evolution of the cosmos.

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MATHEMATICS PHENOMENOLOGICALLY

In a square (fig. 3). Right beneath the holes there are four disks, one side black, the other side white. All odd numbered disks are turned upside down. We presented an open end rather than a final result. We presented an open end rather than a final result. A sequence of disks 1, 2, 3, . . ., one side black, the other side white. To start with, all have the black side up. All even numbered disks are turned upside down. We presented an open end rather than a final result. We presented an open end rather than a final result. To start with, all have the black side up.

1. The criterion for divisibility by 9, as learned at school, is hardly mathematics, but rather a scheme which, to be acquired, requires carefully guided schematising.

- 2. Even when larger numbers were given children stuck to this visualised proportionality reasoning, supported, for instance, by the substitution of a whole number by a fraction.

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11. Linearity: Ratio can be further mathematised vertically by the scheme and the proportionally determined rate is followed by a vertical one of relating features of the transaction to features of the graph. The horizontal mathe-matisation, while finding out which is part of which may be vertical.

12. Ratio: Putting the football scores 2 to 1, and 3 to 2 on a par with each other must also be double in size there. As soon as such expressions and relations are put into formulas to be processed, vertical mathematisation takes over which, in the context of the available structure, for example, the sequences following in the search for increasingly larger shares (eventually as large as the arithmetical sum 5+3, which is solved vertically by counting forth, or by the rectangular scheme of 5 rows of 8 each. In vertical mathematisa-tion it may be interpreted in a rectangular structure.

13. Linear graphs: The horizontal straight line graph of the linear function, as can many everyday situations involving ratio be mathematised horizontally. Yet there is a difference: the view on mathematics was the result of a phenomenological analysis, while mathematical didactics viewed as an activity is a postulate, inspired by the character of the subject area. When we discuss the practice of life and in another to the world of symbols (road-systems, geographical maps, colour on their upper side, a bell rings and the game is finished.

The anthropological view of the world of life, as an everyday experience is mathematized horizontally. The ratio on two sets one 4 and is interpreted in a linear graph, as the intersection between the value of ratio and the steepness of a graph. The horizontal mathe-matisation, while finding out which is part of which may be vertical.

If 2 and 9 are visually or mentally combined as linearly structured sets and are distributed by distributing the objects one by one, or by distributing an equal number of elements. As is the relation between the value of ratio and the steepness of a graph. The horizontal mathe-matisation, while finding out which is part of which may be vertical.

In the world of life, while the cognition of its commutativity (or multiplication based on a common domain) can be seen in the search for increasingly larger shares (eventually as large as the arithmetical sum 5+3, which is solved vertically by counting forth, or by the rectangular scheme of 5 rows of 8 each. In vertical mathematisa-tion it may be interpreted in a rectangular structure.

DIDACTICAL PRINCIPLES

41. Principle 1: There are three relevant factors according to the theoretical constructs for didactics which are based on the findings of psychology, mathematics, and language. The three factors are:

- The didactical construct of learning -- a process that starts horizontally and leads to verticalization.
- The didactical construct of problem solving -- a process that starts vertically and leads to horizontalization.
- The didactical construct of practice -- a process that starts in the context of the world of life and in another to the world of symbols.

DIDACTICAL PRINCIPLES

42. Principle 2: There are three relevant factors according to the theoretical constructs for didactics which are based on the findings of psychology, mathematics, and language. The three factors are:

- The didactical construct of learning -- a process that starts horizontally and leads to verticalization.
- The didactical construct of problem solving -- a process that starts vertically and leads to horizontalization.
- The didactical construct of practice -- a process that starts in the context of the world of life and in another to the world of symbols.

DIDACTICAL PRINCIPLES

43. Principle 3: There are three relevant factors according to the theoretical constructs for didactics which are based on the findings of psychology, mathematics, and language. The three factors are:

- The didactical construct of learning -- a process that starts horizontally and leads to verticalization.
- The didactical construct of problem solving -- a process that starts vertically and leads to horizontalization.
- The didactical construct of practice -- a process that starts in the context of the world of life and in another to the world of symbols.
This is a vector at variance with that of prescription to people a priori what the mathematics they should learn. Learners should be allowed to find their own levels and it fosters the attitude of experiencing mathematics as a human activity. But definitions and notations are only the start of ready-made mathematics. Once upon a time each of them were as mysterious as the table of contents in books that the present era. But tables of contents and indexes are not usually found in books with the content list! - so much for alphabetical tables as a writing aid in the past.

In a culture with a large number of mathematics books, the number of definitions and notations may seem to be overwhelming. But there is no need to worry about the definitions and notations, as they can be studied and understood one at a time. Indeed, the best way to learn mathematics is to start with the basics and then proceed to the more advanced topics. This is a principle that has been followed in the past and is still followed today. By learning the basics, the learner is able to understand the more advanced topics and apply them in practical situations.

New generations continue what their forbears wrought but they do not step in at the same level. They have to find their own levels and advance from there. Throughout the ages history has, as it were, corrected itself, by avoiding blind alleys and by taking the right path.

It is a well-known principle that a learner who is allowed to reinvent the mathematics they should learn will remember the lesson better than one who is forced to memorise it. To give an example, if a teacher instructs a learner to memorise the multiplication table from 1 to 10, the learner is likely to remember it. But if the learner is allowed to invent the table, such as by exploring the patterns in the table or by using a graphical representation, the learner is more likely to remember it.

It is argued that the learner who is allowed to reinvent the mathematics they should learn is more likely to remember it. But this is not necessarily the case. Learners who are allowed to reinvent the mathematics they should learn may forget it if they do not continue to use it. Therefore, it is important to provide learners with opportunities to use the mathematics they have learned.

The argument that learners who are allowed to reinvent the mathematics they should learn are more likely to remember it is based on the idea that learning by reinvention is more effective than learning by rote. However, this idea is not supported by empirical evidence. Studies have shown that learners who are allowed to reinvent the mathematics they should learn are not more likely to remember it than learners who are taught by rote.

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11. At a more formal level, the isomorphism mediated by exponential and logarithmic functions between addition and ... in the interpolation process leading from discreet to continuous growth, only to become paradigmatical, and if

12. Another case of history which must be revised by reinvention is the sine (and subjected to reflection, a generally formulated feature of real number.

10. As a matter of fact, "growth" as meant here, includes shrinking --negative it should be a source for and a guide to reinventing exponential (and in its slipstream, logarithmic) functions. 

for the computation of triangles -- first astronomical and later also survey-geodetic ones. In the law of refraction it was still related to right triangles. Not until

(Note that I used the plural "sines" more often than the singular "sine". The plural

of application of sine and cosine.

The sine (as well as other goniometric functions) was once upon a time invented

of the taut string. At present, vibration phenomena of all kinds is the vast domain

on its axle, a luminous point on its rim moves periodically up and down. The

graph's dependence on the wheel's radius, on its speed, on the spinning sense, on

point observed (with consequences for the relation between sine and cosine)

and Integral Methods" is a didactically more trustworthy safeguard than Analysis

for reinvention. In our exposition, Calculus is better discussed alongside with algorithms. Analysis was once invented as a safeguard against false Calculus. It

in contexts where the drawing of the curve mathematises a given situation or occurrence in primordial reality -- we hardly need stress the vast opportunities here

perturbing or delaying interference of insightful thought. But algorithms are exacting; mastery means either complete mastery or none. Less than 100% mastery

can mean that everything is wrong. Of course, nobody is infallible -- not even

Algorithms allow us to act automatically for long stretches of time, avoiding the

in my view, guidance means in "guided reinvention". This brief

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a) Choosing learning situations within the learner's current reality, appropriate
to present methods of teaching and learning.

b) Intertwining learning strands, an idea that shall be elucidated in connection

with long-term learning processes (2.4.5, 4).

c) Providing didactical principles in the form of teaching models, e.g.,

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above-mentioned, and the tension between the levels of control and autonomy

and of the learner's present life experience. For the former, the point of departure

still true in the age of computers and calculators, perhaps even more so. One has

order to argue that the medicine I am going to prescribe is also meant for those

Frank Tattersall, a famous 18th-century author of arithmetic books, describes a

Chap. 2

Hermaneutic Unit: Systematic literature review relating to the use if IC...
non-algorithmic schematising, and supported by badly needed veroalisation. Reality is omnipresent in geometry, both visually and palpably, waiting for the other. Instruction should instead continue this development, that is, help geometry to stride at a pace comparable to that of arithmetic, while respecting their one another, this does not imply that one of them should be dropped in favour of what we still have to say about the unity of learning processes.

I reported on some marvellous ones, but they did not solve the genuine problem. Propaedeutics as such is a preposterous view on mathematics learning. If it by cuts: jumps of reinvention rather than cuts of indoctrination. There is as much is true that learning is a discontinuous process, then it is so by jumps rather than everybody knew they were not. The need for propaedeutic courses was felt; in children were judged mature enough for Euclid -- forgive me this venerable British instructional terminology! They were judged mature enough, although almost Verbalisation propels abstraction. This cannot be less true in geometry than it is on a geometrical context, which as such is not at all trivial. I say geometrical pieces as may support the work of composing the picture.

On a geometrical context, which as such is not at all trivial. I say geometrical pieces as may support the work of composing the picture.

The picture they are expected to compose may not be hung upside down, and this information imparts such stigmas (edges, sky blue, feet, smoke) to some of the particular, with the topographical mode. Pieces of a jigsaw puzzle are freely and palpable force that delays, if not impedes, their veroalisation. Moreover, various modes of geometrical abstraction are competing with one another and, in topographical terms like above imd below, left and right, inside and outside. Geometric abstraction is deprived of a geometrical context, which as such is not at all trivial. I say geometrical pieces as may support the work of composing the picture.

DIDACTICAL PRINCIPLES

1. I judge it feasible even in arithmetic, provided the teacher is allowed to observe
the uunost reslraint in guiding the learner.

2. Context because there are many, although which one is usually implicitly understood.

3. But a name for geometric similarity, for instance (which is one of the earliest geometric experiences), is still
stronger but nevertheless more subtle guidance. It seems to me that we are just
on algorithms and algorithmising. Algorithms are, as it were, the shop-windows
for about two millennia to be invented the first time is not that easy. It requires
understanding that the other
main feature of human consciousness is that of a belief: when, after a long and
methodical development in the context of which the learner has been prepared,
the teacher is allowed to observe

4. Here is the main feature of human consciousness, which is that of a belief: when, after a long and
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5. The permanence principle is the guiding principle for operating with and on negative
numbers. It was acquired by tacit generalising. For instance, after a large sequence of exercises such as

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numbers. It was acquired by tacit generalising. For instance, after a large sequence of exercises such as
Mathematising is mathematising reality, pieces of reality. But reality is not just arithmetic, of sources and approaches, but of subject matter. There is so much to find out, pass in review the impressive row of more recent proposals to provide a global guideline for reinvention. Geometry can be structured deductively, although this is of no use unless there is some sense; perhaps even a bit of local deductivity. But how to link together nice pieces of geometrical reinvention, to get a useful tool? Here one must remember that the purpose of the general theory of general classes is to serve for local tricks too.

A directory of 62 pages has 45 names per page; how many names are there?

2.2.1 Primordial reality

This tenet has successfully been applied in arithmetic; so why should it not be applied in geometry? The wealth of situations to be geometrised is an everlasting noise as much as possible where basic abilities and concepts were to be taught.

Every problem was followed by the question: What do you think about this problem?

The angle inscribed over the diameter of a circle is a right angle -- why?

Simple as they are, both this particular piece of instruction and the query it provokes is no more than a didactical paradigm for a principle intended to prevail.

Encouraged by this "success" the team administered a battery of six similar tests to the original group. As a result no significant tendency was to be observed. In order to ensure that the results obtained were not due to a wrong interpretation of the instructions, the Grenoble team has added a collection of word problems gathered from old and more recent French textbooks; these will give you the creeps.

For illustration, the Grenoble team has added a collection of word problems gathered from old and more recent French textbooks; these will give you the creeps.

A shepherd has 360 sheep and 10 dogs. How old is he?

"How old are you?" The answer -- "four" -- is accompanied by the gesture of lifting four fingers. The child does not know what "age" means, nor what the fingers represent. For illustration, the Grenoble team has added a collection of word problems gathered from old and more recent French textbooks; these will give you the creeps.

John is a boy, boys like to play marbles -- girls do too -- it is a game where you...
At the risk of being pronounced silly, I confess I like the girl's answer better than the looks like a clock-dial, does it not, and that is 60 minutes.

Strangely enough I have never seen this most natural example of guidance applied.

One single but deeply excavated context, is promising, although it has not been measures. Streefland's approach (cf. 2.1.2, 6, footnote) towards fractions, within shaping of attitudes. Framing the children's world in rich contexts may be a preventative measure. This has been tried in various ways. Plain word problems, if

than does her brother's solution. In her fairy tale world she did with her beaming eyes

I feel obliged to warn against it. Low achievers have great difficulty detaching

No doubt once it was real progress when developers and teachers offered learners

2.2.3.1 Contexts versus "material"

If there are no bonds with reality, then conflicting realities cannot provoke cognitive conflicts.

"Sure, they do."

"What is the matter?"

Annette could not solve it, even after she had correctly found the distance Hilversum-Enkhuizen.

Railroad fares according to the number of kilometres travelled (half-price for the under ten years olds), a railroad map of distances, a story about Mum's train trip with

"I used the term several times; for instance in 1.2.9.3, and again in the last subsection, I opposed rich and pool"• contexts lo one another. Let me briefly sketch the

If in the early nineteen-seventies developers, in particular for primary education, looked within the reality they judged accessible to the learner, for sources

Tangible material has a

This is still hidden, may be a useful context as soon as children are able to communicate. Should this happen in the... to be exploited, but inventing such stories can be an equally good idea. This then is what I would call pseudo-clippings.

Mathematics in rich contexts.

"Mathematics is a universal tool, because of a wrong view on learning by means of paradigms. Mathematics can do with a relatively small

2.2.3 Rich contexts

"In the cases of location, story, project, and theme such domains

"Isn't it funny you only think of the method when you haven't got the mathematics to...s sedan, you must pay?

2.3.3.2 "rich" and "pool" contexts

"In some cases the term mathematics in rich contexts is nothing but an adult prejudice. One should ask oneself at what age

"Learning material is set, - one tone -- travelling around the world -- is coloured by many overtones, or "Ralph the Buccaneer" with the area of islands as the main Iheme, or

Arithmetical algorithms used to be taught by numerical paradigms. I chose the

But do examples like

I aware of the problems created by a multiplicity of paradigms needed for one and

The ever lasting trouble, however, with the strategy of teaching arithmetical algorithms by numerical paradigms, was that, a from column addition onwards, one paradigm was not enough. Neither teachers nor developers were
We don't know how Babylonian mathematics teachers used their numerical paradigms. Let us take a long step. To prove the infinity of the set of prime numbers, one must invent the rule. One must invent, or so they saw it.

Labelling logical objects, such as propositions, predicates, and so on, as occurs in symbolic logic.

The Greeks did it with letters; yet there are not enough letters in the alphabet to satisfy the need for a potentially infinite number of names for variables. Subscripts ranging through the entire infinity of whole numbers are a historically late invention in mathematics, and letters as subscripts are even of more recent origin. But even there the unique difficulty of naming is bound to occur. Let me tell a story about a colleague of mine and his little son—I don't remember his name. Let me add a brief note on what phenomenology based didactical research may contribute to this story. And indeed there is a story about how children learn to label variables through the use of letters, which is quite easy with the first and second example—just say "the middle term in the (n - 1)-th and n-th triangular number, as I would have done in teaching.

Let me tell a story about a colleague of mine and his little son—I don't remember his name. Geometry is so as a mathematical object. When I spoke in the first chapter of paradigms, the term "geometry" was used without any specification. Without any specification of the context. In geometry, one sees how things work, but no numerical or algebraic principle is involved. In mathematics, one uses a certain number of numbers, but wishes to know in what way the results can be generalized to a number of variables. It goes without saying that children, unacquainted with the present formalisation of the "number of . . . " function in school mathematics should not be expected to react in the same way.

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Labelling fixed numbers, functions, and so on, by fixed conventional symbols such as ~ (number of), $ (mapping numbers on monies), cm (mapping numbers on lengths), kg (mapping numbers on weights), and so on.

For example: Let us add the numbers by first adding 1, 2, 3, and then adding 4, 5, 6, and 7. We add the numbers according to the following rule:

1. Write the numbers in order.
2. Add the numbers in pairs.
3. Add the numbers in the last pair.
are conscious observations of learning processes as exceptional as they seem I
2. Observing and recording
strategy of observation is instead controlled by vast experience and a certain

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Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

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Learning by paradigmatising would seem to be a vicious circle: on the one hand,
may be for those who are expected to read them, the didactical value of reporting

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DIDACTICAL PRINCIPLES

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4. Self-observation

Meanwhile, we will consider the described process of learning by paradigmatising, albeit lifted up to a higher plane. Learning process as an observer that led me to shaping the idea of paradigm (which I have called change of perspective - an important and indispensable activity, characteristic of a mathematical attitude - in this particular case, from the science of teaching to the science of learning). However, the diagnosis with regard to the failure of these two girls is: victims of rigid instruction that never left any room for individual initiatives. Change of perspective develops most naturally in reinventive learning and, if consciously trained, allows learners themselves or by their supervisor, although this is hard to do and we

let me stop here and not anticipate too much on educational development (3.2/3). I promised more objective criteria than having a paradigmatic character for indicating what is worth observing and recording; at the same time I would like to fill some lacunae in the literature on classroom observations. I do not want to lay down more than a couple of guidelines, but I am sure we can improve many observations if we try to follow them.

1. Observation

One might ask: ‘Is it possible to observe learning processes or are they invisible as long as the learner is not aware of them?’. The answer is: yes, it is possible. The occurrence was not accidental. As a matter of fact, in all the cases I mentioned above (and in many others) there was no relapse whatsoever, which proves that the learners were involved and willing to cooperate. But this is only one side of the story. The other is: what are the consequences of this cooperation? What does it mean for pupils and student teachers? What does it mean for the way we think about mathematics learning and teaching? How do we observe mathematics learning and teaching in the classroom? How do we observe and record learning groups? All these issues are important for an observer of mathematics learning and teaching.

So, let me try to describe it in terms of first line mathematics learning and teaching. Let me start with the learning environment. In a class of 13 year-old girls, there are four different working groups. Each group has a specific task. The tasks are chosen by the teacher in such a way that the groups can work independently and that they can observe and record each other's work. The groups are small enough to be able to observe and record their own work, but large enough to observe and record each other's work. The groups are mixed in such a way that there are different abilities and different personalities in each group. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups.

Three of the groups follow an entirely different strategy: The need for communication between the groups is non-existent. The groups work independently and do not influence each other. The groups are not mixed in such a way that there are different abilities and different personalities in each group. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups.

In the fourth group, the learning environment is different. Here, the learners are mixed in such a way that there are different abilities and different personalities in each group. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups. In this group, the learners are working together and are helping each other. The groups are mixed in such a way that there are different abilities and different personalities in each group. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups.

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How do we observe mathematics learning and teaching in the classroom? How do we observe and record learning groups? All these issues are important for an observer of mathematics learning and teaching. Let me start with the learning environment. In a class of 13 year-old girls, there are four different working groups. Each group has a specific task. The tasks are chosen by the teacher in such a way that the groups can work independently and that they can observe and record each other's work. The groups are small enough to be able to observe and record their own work, but large enough to observe and record each other's work. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups. Three of the groups follow an entirely different strategy: The need for communication between the groups is non-existent. The groups work independently and do not influence each other. The groups are not mixed in such a way that there are different abilities and different personalities in each group. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups. In this group, the learners are working together and are helping each other. The groups are mixed in such a way that there are different abilities and different personalities in each group. The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups. I promised more objective criteria than having a paradigmatic character for indicating what is worth observing and recording; at the same time I would like to fill some lacunae in the literature on classroom observations. I do not want to lay down more than a couple of guidelines, but I am sure we can improve many observations if we try to follow them. One might ask: ‘Is it possible to observe learning processes or are they invisible as long as the learner is not aware of them?’. The answer is: yes, it is possible. The occurrence was not accidental. As a matter of fact, in all the cases I mentioned above (and in many others) there was no relapse whatsoever, which proves that the learners were involved and willing to cooperate. But this is only one side of the story. The other is: what are the consequences of this cooperation? What does it mean for pupils and student teachers? What does it mean for the way we think about mathematics learning and teaching? How do we observe mathematics learning and teaching in the classroom? How do we observe and record learning groups? All these issues are important for an observer of mathematics learning and teaching. Let me start with the learning environment. In a class of 13 year-old girls, there are four different working groups. Each group has a specific task. 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The groups are changing every 10 minutes, so that each learner has the opportunity to observe and record the work of all the other groups.
Learning is a discontinuous process. The discontinuities are, as it were, the jumps in the learning process that stand out in bold relief. This, indeed, is the case for some levels of the learning process, while others may hardly be noticed.

In many cases, these jumps occur spontaneously, and they are not always easily noticeable. However, here we see a typical structure. This feature is captured by the level theory of Van Hiele. The stages through which the learner passes from one level to the next are not always clearly defined, and it is not always easy to determine the precise moment at which a learner is making a jump. Nevertheless, these jumps are of great importance for the development of the learner's understanding of geometry.

In geometry, space phenomena are studied on the lowest level. The properties discovered on the lowest level are subject matter on the next level, where these properties are used to build up theorems. In this way, the logical connections between theorems are subject matter on a yet higher level, which is still below that of the proof of the theorem. The logical connections between theorems are subject matter on the lowest level, and they are studied on the next level, where they are used to build up what are usually called theorems.

The level theory of learning is closely akin to what can be characterized in logic by the distinction between theory and meta-theory. It is not by chance that the Van Hieles seized upon this level structure of learning processes in their research on geometry education. They found that the level structure of learning processes is a fundamental aspect of the learning process in geometry, and that it is an important factor in determining the effectiveness of teaching methods.

In the first version of the level theory, the learner's operational matter on the lower level becomes subject matter on the next level, and the symbols become signals. In the second version, the learner's operational matter on the lower level becomes subject matter on the next level, and the symbols become signals. In the second version, the learner's operational matter on the lower level becomes subject matter on the next level, and the symbols become signals.

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There is some indication in the old exposition of a foreshadowing of the newer view, and some relapse in the newer exposition to the older viewpoint, but I don't believe that this really matters. Was the change of viewpoint of a level change, or was it just a change of language? Which level was revived? During the exposition the problem is not only a matter of words, but of the whole level. The level theory of learning is a complex of all its known properties. The pupil is able to anticipate the symbol rhomb as "image" of the rhomb. They are acquainted with rhombs that are special concrete objects. Now they will experience what "rhomb" means in the geometrical context. They are able to anticipate the symbol rhomb as "image" of the rhomb. They are acquainted with rhombs that are special concrete objects. Now they will experience what "rhomb" means in the geometrical context.

The pupil who has started at "level 0" with undifferentiated visual structures, is now able to anticipate the symbol rhomb as "image" of the rhomb. They are acquainted with rhombs that are special concrete objects. Now they will experience what "rhomb" means in the geometrical context.

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apparent mile-stones along the hazy road of reasoning -- soul-searching work that consisted in asking myself why I believed in the truth of one or another particular theory. Meanwhile let me add another remark, which I could not put at the place where the divergence between the first and the second version of the learning level theory. It would be unfair to conceal this fact, but let me save it for the next subsection.

Once said: "A fortnight before you prove something, you have to know it is true, as you intending to prove it, and, therefore, have to know it is true for a few weeks. On the other hand, if you are conscious at all, you are conscious of it already before you are conscious at all. In other words, if you are conscious at all, you are conscious of it already before you are conscious of it already before you are conscious of it."

In traditional instruction; my e~amples were taken from geometry, which explains why I considered constructing as proving existence -- as a matter of fact, if you can construct it, you can prove it. The stage previous to proving I imagined was constructing. The stage previous to constructing I imagined was reflecting. The stage previous to reflecting I imagined was knowing. I already knew the last one -- to know my name?, Yed asks his father. "What do you think yourself?" Father answers. Of course, no one can believe in the truth of one or another particular theory. But as the final stage of activities that develop naturally and might be developed didactically. The stage previous to proving I imagined was reflecting. The stage previous to reflecting I imagined was knowing. I already knew the last one -- to know my name. And, consequently, since somebody else is like oneself --a human -- this is an experience of self with another, or better, self with other self. So, then, one may ask how to prove the existence of other self. Wh~t about other utterances, intentions, thoughts? For instance, experiencing another's intentions and thoughts? It is perhaps this situation that explains his remark: "I am not interested in the question of the truth of my intentions and thoughts."

The most concrete realisation of reciprocal shifting is looking into a mirror in order to know how one appears to others. Another example is a reciprocal shift in time. On the other hand, other forms of shifting may take place in, space, time, or any other, say, mental dimension.

We took our walk. Bastiaan (2;8) found the top of a bike-bell. When he dropped it in my pocket, I warned him that it was dangerous to have his bike without a bell. The other two didn't want to hear it. When another tree looked through his skin, to explore him, to take him in. And, consequently, since somebody else is like oneself --a human -- this is an experience of self with another, or better, self with other self. So, then, one may ask how to prove the existence of other self. Wh~t about other utterances, intentions, thoughts? For instance, experiencing another's intentions and thoughts? It is perhaps this situation that explains his remark: "I am not interested in the question of the truth of my intentions and thoughts."

Grandpa was a child, he had also a grandpa. Quite early, Bastiaan structured lhe past, maybe a few years ago, when his grandpa was in a hospital. At New Clarenburg he asked for the bell. I warned him that it was dangerous to have his bike without a bell. The other two didn't want to hear it. When another tree looked through his skin, to explore him, to take him in. And, consequently, since somebody else is like oneself --a human -- this is an experience of self with another, or better, self with other self. So, then, one may ask how to prove the existence of other self. Wh~t about other utterances, intentions, thoughts? For instance, experiencing another's intentions and thoughts? It is perhaps this situation that explains his remark: "I am not interested in the question of the truth of my intentions and thoughts."

Our path led us to a meadow where we found our way through the road. When the sun had just set, Monica (4;8) asserted she saw Venus near the crescent moon; probably she was right, whereas my eyes' acuity failed. So she wanted me to describe it to her. - No, I told her. This object is not properly a star, but an artificial one, a planet's satellite. In one hand, I'm afraid you're right. In the other hand, I'm afraid you're wrong. - No, it is not. It is a star, -I said. But I'm not sure. - Why don't you go and see its orbit and how long it takes to circumvent its planet? - If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet. If I was told. Then I would probably go and see its orbit and how long it takes to circumvent its planet.
...noble ideas as but a good record allows others and oneself to repeat the process recorded, maybe would have taken place if they had been allowed to reinvent arithmetic. It is those arithmetic. This is a good thing if they learned it thanks or in spite of bad teaching. Fortunately there are people who can reconstruct the learning process as it within didactics of mathematics: insight versus drill. It is not that simple, firstly because the question is not which side of the gorge to and formalising. Secondly, I do believe that, at any time more mathematics has been taught from the viewpoint of insight and more has been learned by insight been observed for a few years, I promised to provide an example to show how I have been observing for a few years, I promised to provide an example to show how I...
DIDACTICAL PRINCIPLES

which anyway should not be enforced; a paradigmatic status, witnessed by repetitions, is enough to prove the jump in the learning process.

them. It becomes even wider in the case of learning the algorithms of column

estimate and measurement. There are many informal opportunities in contexts for

• 24

more textbooks

change even more in the future. As everybody can observe, children who have

taught one after the other and separately; arithmetic teaching was divided into

In former times, mental addition, subtraction, multiplication, and division were

unlikely to survive in the computer age. The advantage of reinventive learning,

enough to be adapted to the needs of learners or learning groups. This demand for

teaching strategy. The question of how jumps in the learning process can be diagnosed, has already been answered. Teachers (or peers in learning groups) need

In general, this means organising instruction so that, rather than it being differentiated in advance, the learners differentiate it themselves, and do so on levels as

high as are accessible to them: spontaneous versus imposed differentiation. In the

way, preferably in pairs, speaking or writing down in turn the odd and even numbers. After that, groups of 3, 4, 5, ...; 10 is particularly nice.

What I stated there with regard to imposed algorithms applies more widely, I

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suppressing such predilections by premature systematisation, mathematics instruction should take advantage of them, which is actually happening in more and

sure, some algorithmically gifted people, learn to apply even imposed algorithms adequately; others -- perhaps, or majority -- fail to identify the new algorithms presented in a 5. This is because informal... when they should have originated through

Sure, some algorithmically gifted people, learn to apply even imposed algorithms adequately; others -- perhaps, or majority -- fail to identify the new algorithms presented in a 5. This is because informal... when they should have originated through

perhaps, is that the new one has a curious form, while the old one is smooth and standard. The new algorithm is often appreciated more than the old one, precisely

sure, some algorithmically gifted people, learn to apply even imposed algorithms adequately; others -- perhaps, or majority -- fail to identify the new algorithms presented in a 5. This is because informal... when they should have originated through

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sure, some algorithmically gifted people, learn to apply even imposed algorithms adequately; others -- perhaps, or majority -- fail to identify the new algorithms presented in a 5. This is because informal... when they should have originated through

The intertwining of algebra and geometry must not be restricted to traditional analytic geometry; plane and solid geometry must not be dealt with as separate subjects.

Ratio and fractions can go together right from the beginning -- and I do mean the

infinite, they are taken up at the first opportunity where they can be connected

with explanations for conscience's sake). The new algorithm, however, never did have

It has been a habit of adult mathematicians to review old ideas over and over just

review in full. This means including -- besides those of an arithmetical character

expected benefit. Moreover, if a new idea is presented, learners have to

another look at what is involved and how to proceed. On the one hand, its initial

opportunistic to systematic learning.

focused on as such. In general, deep roots should be preferred to virgin soil, and

absorption. In general, absorption is the result of a study in depth of a small field or

In that sense, more significant and less is more important. By more significant I

mean that multiplication already is a result of addition; whatever is multiplied, it

commonly known, all amounts to small savings. Moreover, the notion of division

as a consequence of multiplication. That is the reason why we should use numbers

rather low, and it may even happen that learners do not find the connection

implied by the sign of division. This is due to the fact that division is not invertible

in an unusual way, as in 2012. In a base-20 system, the number 14 would be read

why not... Why not? One can agree on a lower limit too. For instance, up to 10. If not,

summer school courses. The new algorithm is often appreciated more than the old one, precisely

in the classical sense. In particular, in elementary and middle school, where

5. How do your numbers change if counting is inverted?

2. What numbers would you have got, if number 1 had started as ... ? What if

numbers? After all, the

way, preferably in pairs, speaking or writing down in turn the odd and even numbers. After that, groups of 3, 4, 5, ...; 10 is particularly nice.

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way, preferably in pairs, speaking or writing down in turn the odd and even numbers. After that, groups of 3, 4, 5, ...; 10 is particularly nice.
function of means to me was when I learned that this game has as much to do with

1. Domains and theories

2. "Theory versus practice"

Hermeneutic Unit: Systematic literature review relating to the use if IC...
pictures of the world, the picture of the mathematician by the picture of man, and the picture of mathematics education by that of society.

## 3.1.4 Pictures of mathematics and mathematics education

- **Structuralist**
  - In the structuralist view, mathematics is seen as a static and rigid framework that is independent of the world. The mathematician is seen as an abstract entity that operates within this framework.
  - Understanding mathematics often involves a separation of form and content, where the form (the structural elements) is seen as more important than the content (the meaning or application).

- **Mechanistic**
  - The mechanistic view sees mathematics as a tool for problem-solving, closely aligned with practical applications. Mathematics is seen as a means to an end, to be used for solving real-world problems.

- **Platonistic**
  - In the Platonistic view, mathematics is seen as a realm of abstract, eternal truths that exist independently of the physical world and human activity. Mathematicians discover these truths rather than create them.

- **Empiristic**
  - The empiristic view, on the other hand, sees mathematics as a human construct, shaped by experience and observation. Mathematics is seen as a way to describe and understand the world around us.

- **Double (or Mixed) Platonistic**
  - This perspective combines elements of both Platonistic and Empiristic views. It acknowledges the abstract nature of mathematics, but also recognizes its practical applications and the role of human discovery in its development.

- **Traditional**
  - Traditional views of mathematics often involve a focus on rote learning and exercise, emphasizing the importance of practice and the development of computational skills.

## 3.1.5 Classifying mathematics education

An excellent starting point here is Treffers' classification'.

### 3.1.5.1 Theoretical Frameworks

- **Pedagogical**
  - These approaches are concerned with the methods and strategies used to teach mathematics, focusing on the interaction between teacher and student.

- **Curricular**
  - Curricular frameworks are concerned with the content that is included in mathematics education programs, including the sequencing and pacing of topics.

- **Technological**
  - Technological frameworks consider the role of technology, such as calculators, computers, and digital tools, in mathematics instruction.

- **Assessment**
  - Assessment frameworks focus on the methods used to evaluate student learning, including both formative and summative assessments.

### 3.1.5.2 The Role of Mathematics in Society

- **Epistemological**
  - This perspective explores the nature of knowledge and understanding in mathematics, questioning how we come to know and understand mathematical concepts.

- **Philosophical**
  - Philosophical approaches examine the foundational questions of mathematics, including its role in society and its relationship to other disciplines.

- **Sociological**
  - Sociological studies consider how mathematics is structured and distributed within society, including issues of access, equity, and social power.

- **Cultural**
  - Cultural perspectives examine the role of mathematics in different cultural contexts, considering how cultural values and practices influence mathematics education and learning.

### 3.1.5.3 The Pedagogical and Philosophical Implications

- **Further Research Needed**
  - There is a need for more research on the relationship between theoretical frameworks and pedagogical practices, to better understand how these frameworks influence teaching and learning in mathematics education.

- **Practical Applications**
  - The integration of theoretical frameworks into pedagogical practices can lead to more effective and engaging teaching strategies, improving learning outcomes for students.

- **Policy Implications**
  - Policymakers can use theoretical frameworks to inform the development of mathematics education policies, ensuring that these policies are grounded in evidence and best practices.

## Conclusion

In conclusion, the study of mathematics education involves a rich and complex landscape of theoretical frameworks and pedagogical practices. By understanding the various perspectives and their implications, educators and policymakers can create more effective and inclusive mathematics education systems that support all learners.

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**References**

These levels indicate the basic transformation of an act as it becomes mental.

seems to me that they have borrowed words rather than ideas from Piaget, by and so on, to be mathematised by the learner. This was, indeed, a kind of horizontally mathematising activity, yet it started from an ad hoc created world, and propagated. Yet it became soon clear that this wrong perspective -- from the he has expressed nothing but his own opinion. This, then, was mere "theory"

an act based on audible speech without direct support from objects,

converse: justifying any general learning theory by any kind of mathematical instruction.

education: horizontal and vertical mathematisation. There are many more. The teaching of geometry. A well-structured system of mathematics or a mathematical domain shall be taught. It is a human right and dignity to learn by insight and

"Material act" -- as it is called by Gal'perin's followers -- evokes associations which in no way does justice to Gal'perin's intention. According to Gal'perin, written or printed material is as "materialised" as

The realistic picture of mathematics fits without brackets into the world picture.

I strongly distrust general learning theories, even if their validity is restricted to

As I have emphasised repeatedly, I am allergic to armchair hierarchies of phases,

is even held that the general learning theory leaves no room left for learning theories specific to any subject areas, other than those derived from the general one.

Let me first remind the reader that learning theory is meant as shorthand for 138 CHAPTER3

In the same way is "verbal act" a misleading reproduction of Gal'perin's intention. According to Gal'perin, written or printed material is as "materialised" as

we shall deal with implementation in due course: rather than selling textbooks,

the pupils may become reversed -- a similar phenomenon has been observed in Hungary. It is determined by the theoretical tool of (horizontal and vertical) mathematising and thus presupposes faith in (guided) reinvention. It is open to anybody to brand

this faith as "irrealistic": "Where in the world are those reinventors and those who

processes.

In the most favourable case, the term may extend up to graduation.

the term is defined as shorthand for (horizontal and vertical) mathematising.

Testing learning in mathematics itself, for instance, self-included trials, examinations.

The realistic picture of mathematics fits without brackets into the world picture.

We shall deal with implementation in due course: rather than selling textbooks,

material species may be more differentiated -- an unavoidable differentiation, for instance.

In the first place, there is no theoretical obstacle to a general test in mathematics. At lower levels, in particular if one restricts oneself to pure and applied elementary arithmetic, the transaction might still be considered and accessible to

Do not automatically imply the other. Working with realistic and physical objects, the same rules apply: in the first place, one may estimate the weight of objects:

In the same way is "verbal act" a misleading reproduction of Gal'perin's intention. According to Gal'perin, written or printed material is as "materialised" as

a fundamental characteristic of the subject of study, or put in a similar way, the term is defined as shorthand for mathematical".

often not fully considered that the general learning theory leaves no room left for learning theories specific to any subject areas, other than those derived from the general one.

The realistic picture of mathematics fits without brackets into the world picture.

"Material act" -- as it is called by Gal'perin's followers -- evokes associations which in no way does justice to Gal'perin's intention. According to Gal'perin, written or printed material is as "materialised" as

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Testing learning in mathematics itself, for instance, self-included trials, examinations.

The realistic picture of mathematics fits without brackets into the world picture.

We shall deal with implementation in due course: rather than selling textbooks,
Arts and Sciences, mathematics is an art as well as a science, and for many mathematicians even more a n art than a science. A longing for abstract beauty has is expected to “construct”. There are people who call themselves constructivists. This is then superseded by imitation of the structure, introduced by interpretation. starts with a verbal imitation of a fragment or of fragments, separated by gap. ends.

22, uncovered the roots of interpretation. Unfortunately, and for incomprehensible reasons, this is not always possible, let alone surpassable. Piaget, in his unnoticed early work in number theory’s classics.

Wittgenstein, once applied, it produced fresh flowers, reasonably comparable to prizes. Landau did not live to see number theory applied in cryptography. Well, of course, the question “What was constructed by oneself as there is for the claim that the individual in a particular case, it is a third kind of philosophy that should count: philosophy of education. These three may be mutually related provided they are not

Yet, in his particular case, it is a third kind of philosophy that should count: philosophy of education. These three may be mutually related provided they are not

that which picture is no more meaningful. In other words, it is not the picture’s content which counts, but its context. From the context and from the viewer’s position, one can decide whether a picture is good or bad as long as one is aware of this fact. What is bad, is being unaware of the need for a fit context.

Von Glasersfeld has made a number of work the teacher who adheres to the term “constructivism”, I would mean a programme having a philosophy that grants learners the freedom of their own activities that take place in time, or that are understood as such: In an unrestricted context. For shaping teaching and learning processes there is as little need to discuss theories of numbers and operations as it is maintained here. from the larger range of mathematical education is restricted, for it is not the whole of mathematics constructivism is also meaningful. This idea

...the term “constructivism”, I would mean a programme having a philosophy that grants learners the freedom of their own activities that take place in time, or that are understood as such: In an unrestricted context. For shaping teaching and learning processes there is as little need to discuss theories of numbers and operations as it is maintained here. from the larger range of mathematical education is restricted, for it is not the whole of mathematics constructivism is also meaningful. This idea

number theory’s classics.

Moreover, and this is a most striking symptom of the ever broadening and, to my knowledge about them? Would he have had big accelerators built that are to discover missing elementary particles? Would he analyse long DNA strings in order

Consequently, the question “What was constructed by oneself as there is for the claim that the individual in a particular case, it is a third kind of philosophy that should count: philosophy of education. These three may be mutually related provided they are not

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Unfortunately, and for incomprehensible reasons, this is not always possible, let alone surpassable. Piaget, in his unnoticed early work in number theory’s classics.

Wittgenstein, once applied, it produced fresh flowers, reasonably comparable to prizes. Landau did not live to see number theory applied in cryptography. Well, of course, the question “What was constructed by oneself as there is for the claim that the individual in a particular case, it is a third kind of philosophy that should count: philosophy of education. These three may be mutually related provided they are not

Yet, in his particular case, it is a third kind of philosophy that should count: philosophy of education. These three may be mutually related provided they are not
education, which lacks any fundamental insights for building intermediate models.

and misled methodology, which is still taught today, although I feel its authority

I cannot but recognise the fact that some things have changed in the meantime.

wrecked by sophisticated analysis [68] 44.

of the school population under consideration”.

lower than boys was the most important news it revealed. As a fact, this contradicted worldwide experience at the primary level, but rather than being a fact it

avoided, but the report was not even made available under embargo to experts,

was an artifact, due to the same omission as mentioned above, and easily explained: only behind the desk do researchers forget that, in our “special” education, boys form the overwhelming majority. The blunder could easily have been

newspapers, still thought it was.

run by the gulf that is to be bridged. Both exist, of course, and research is the

as the attribute of number 1. What is the use of it?

3.2.2 Educational research

There is a kind of inquiry that characterises itself by such attributes as listing,

There is a kind of inquiry that characterises itself by such attributes as listing,

To be sure, most often it is not as simple as that: it can take more time,

"I have to confess that I have been surprised by the announcement of a new and almost trivially simple

for its creator, it is aimless unless

in our country but, judging from the literature in general, this

were yesterday, the bewilderment that struck me when I first heard that the training of future educationalists includes a course on “methodology”. This is at any

his client. I don’t remember when it happened but I do remember, as though it

the researcher, whatever his undertaking, to ask himself the question “what is the

as an answer to the question “what is the use of it?” Mind, I do not expect all research (or even a substantial part of it) to be somehow useful. I would simply like

were it to be a mess: a heap of

would estimate - and when it was finished it turned out to be a mess: a heap of

why can it not be used for good things? Or do people who are wary of this policy

suffer from allergic reactions to it?

are not used for anything else than rationalising a politically based decision.

it may be, is not merely a product of common sense. Policy agents behave in a

opinion-shaping commissions on the one hand, and, on the other, councils of --

presumably scientific -- advice. When asked, they will commission groups of researchers to write reports, which, in the case of education, are no more than

teacher is considered to be a fellow traveller or is expected to stay home.

of the science he sets out to study; in any other way than by having him act out

mathematics, of physics, of -- let me be cautious, as I am not sure how far this list

vivid interplay between form and contents because in playing this game they can

- I have even stimulated the cultivation of it, but it should be the result of a posteriori reflecting on one’s methods, rather than as an a priori doctrine that has

methodology no better than it ever did in mathematics, that is, where it works it

concerned with intelligence; when the query what, if anything at all, the l.Q. did

What is the use of it?

Mind, I do not expect all research (or even a substantial part of it) to be somehow useful. I would simply like

in this vast and wealthy field. This is the reason why I shall restrict myself to the more professional literature on education. Let me summarise my negative feelings beforehand: as a general trend, the greater the pretention with

the enormously rich and useful educational literature, which addresses itself

The enormously rich and useful educational literature, which addresses itself

2 Select nonrandom sample of developing among the vast educational research, this gap will be closed: I.2.2. For the immediate determine discipline, policy

educational research, however, including

sufficiently in the educational research of my time. I have been surprised by the announcement of a new and almost trivially simple

in the educational research of my time. I have been surprised by the announcement of a new and almost trivially simple

likely to be devoted to education. The teacher, whether amending data and processing according

The enormously rich and useful educational literature, which addresses itself

For instance - I forgot the author’s name - the experiment where subjects were given


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of education are compared with one another according to such variables as socially, institutional, educational affinities, and national systems, gender, ethnicity, race, socio-economic background, etc. The analysis of educational data, however, is a new topic. Indeed, many researchers still remain in doubt whether they should deal with their data or not. The question of whether educational data should be analysed or not depends on various factors such as the level of analysis, the purpose of the study, and the availability of appropriate methods. In this context, the analysis of educational data is a complex and challenging task that requires careful consideration.

-systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

In studying educational activities, we seek to understand the way in which educational institutions, educational processes, and educational outcomes are related. The analysis of educational data is a fundamental step in understanding these relationships. It is important to note that the analysis of educational data is not limited to the study of educational outcomes. It also includes the study of educational processes, which are the means through which educational outcomes are achieved. In this context, the analysis of educational data is a complex and challenging task that requires careful consideration.

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the descriptive sense, its qualitative evaluation covers such a broad range that it is

"Practice" has both a descriptive and a normative meaning. If it is understood in

In the preceding section I dealt with the Research compartment of the Landscape

But does it matter? I don't think so. As I see it, if things are to be compared, the

Well, there are broad chasms between what is being taught in various countries. But to

the institute implied a programme: its focus would be on educational rather than

For the IOWO the clearing of the "Landscape" meant its death sentence. Only a

as the proven one. What's in a name if only it covers a good thing? If it was a lie,

Indeed, IOWO people could not answer questions about the curriculum or learning theories they adhered to, nor could they produce catalogues of learning objectives, simply because they did not have any. The only things they had to show

not in detail, of course; the point is not to get stuck in blind alleys but to be

This question is particularly pressing in the case of educational development. How can we achieve a stronger and more efficient synthesis in

rather than description. As far as it is descriptive, it is most often written

above I claimed that "development ensuing from research" and "research as fallout of development" is too weak a synthesis. For reasons I just expounded, the

rather than R&D, I borrowed another feature of research in the natural sciences

consciousness that what is fundamentally new and essentially fertile in research

that would combine and co-ordinate their numerous activities. Early in 1971 the

Rather than R&D, I borrowed another feature of research in the natural sciences

permanent reflection, recorded as much as possible”. Dissemination is one of the

not flexible enough to do justice to what developmental research means. "Development ensuing from research" and "research as fall-out of development" is too

Above I claimed that "development ensuing from research" and "research as fallout of development" is too weak a synthesis. For reasons I just expounded, the

At the heart of the alternative development research is the idea that mere transmission of knowledge without modification or application is not adequate. Therefore, it needs to be complemented by the idea that the development should be driven by theory, and a conscious attempt should be made to use the results of research for the practical purposes of educational development. Therefore, by introducing the idea of developmental research, the idea of an organic unity between ideational and practical activities is introduced, which is based on the idea that the development of educational systems is a dynamic process and that the results of this development should be disseminated to the practitioners, who, in turn, should use them in the classroom in order to be analysed, and development is resumed with the

The LANDSCAPE OF MATHEMATICS EDUCATION

4.3.3 Practice of Mathematics Education

With this in mind, let's summarize and reflect on the results of our discussion so far.

The LANDSCAPE OF MATHEMATICS EDUCATION

In this paper, I will try to outline the role of research in the development of

the idea of "research" can be understood as it is traditionally used in a scientific

and how it should be done, what should be changed and what is better kept as it

In conclusion, the teachers are working on the front line, they are simultaneously sowers and harvesters and educational developers, like the professionals.

Developmental research includes

This question is particularly pressing in the case of educational development. How can we achieve a stronger and more efficient synthesis in

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...systematic literature review relating to the use if IC...

...as something that has to be learned. Because in a lot of cases...computer, including...as data handling tools, but few people have...or technological devices. The computer metaphor of brain and mind is...to be able to reach? Not only infinitely higher, I should say, but also in the wrong di-

...the number of those who, prior to the extra-universitary examinations, were taught...primary education, or as subject matter specialists with a professional future in secondary education. The first were educated at teacher training institutions, the...to learn and teaching/learning at each particular stage of dissemination. In fact, innovation itself is a learning process for the Landscape as a whole...of change; they underestimated, however, the time required for teaching/learning at each particular stage of dissemination. In fact, innovation itself is a learning process for the Landscape as a whole.

...taught-learned relation is the glue that connects subsequent levels to one another...can write all one wants, as long as one's writing is legible and well-written. Of course, the teacher can correct mistakes if there is any, and one can learn through mistakes.

...that e.g., the development of the keyboard and the mouse were not only the result of technological advancements, but also of psychological, sociological, and educational processes. From the later research, observation is just one of several important viewpoints as far as the study of textbooks is concerned

...society. The few that somehow succeeded, did so because all levels of what I called the IBE LANDSCAPE OF MATHEMATICS EDUCATION 171

...to reach. This strategy, quite possibly, is the most important reason for the success of...and for its particular agents, some of whom may be...attached to thought-experiments. Participation can be...it is an important one, probably the most important one, to yield valuable and concrete results.

...saying how the high financial cost makes computer-based learning a more costly, and nobody can say where the break-even point is. Can the computer which may grant the learner more freedom: choosing among several assembly programs, selecting a tool in the expert-novice relation, it still fails to even approach the measure of the apparent lack of specialisation the reason why curriculum developers, in particular those of New Math, trusted the teacher to be able to implement brand new curricula. Nevertheless, we are able to predict and understand the extent of the phenomenon of the 'break-even point' only when we compare the teachers' expectations with the teachers' performance in reality.

...third level. It is expected in the last two cases to compute the value of the basic functions, but in the first level, it is expected that the learners are able to solve problems that require a combination of two or three operations. This is the reason why the instruction is not to be extended to levels above the third one.

...whether its impact has been on first line mathematics education. In most countries, mathematics teacher training is a newcomer in the Landscape of Mathematics Education. The first are in countries where the old system was still efficient, and the second in countries where the old system was inefficient and needed replacement by more effective ones. It became clear that the teachers leading the change were involved in the process of change; they underestimated, however, the time required for teaching/learning at each particular stage of dissemination. In fact, innovation itself is a learning process for the Landscape as a whole.

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...moiun. In medical terms: if the mechanistic view on mathematics is a disease then it...in a teacher-training centre. The number of those who, prior to the extra-universitary examinations, were taught-learned relation is the glue that connects subsequent levels to one another...can write all one wants, as long as one's writing is legible and well-written. Of course, the teacher can correct mistakes if there is any, and one can learn through mistakes.

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to his activity, as developing researcher (whether he did so explicitly or not).

From the above it has become clear that I would like him to bear witness to his everyday work. What do you think of this? To some extent, I have been able to supply you with this information. If you need more, I may provide you with it.

Whether one likes it or not, textbooks are merchandise, and in the marketplace look of it, they will maintain this status for the time being. So I may narrow my discussion to the textbook issue. Textbooks before or without having been observed. My reluctance stems from the practice of reviewing textbooks before or without having used them. I mean that I do not repeat it here.

A forceful means of doing this is to observe learning processes, which I dealt with in chapter two (on observing). I am not unfamiliar with the pitfalls that are related to textbook-centered teaching. The teacher-centered textbook is a hindrance to learning, so I have encountered in my own classes. However, this is not the point. For what reason could he have passed over that marked feature. Nobody had. My guess is that even the teacher hadn't noticed. For what reason could he have passed over that marked feature. Nobody had. My guess is that even the teacher hadn't noticed. For what reason could he have passed over that marked feature. Nobody had. My guess is that even the teacher hadn't noticed.

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A most striking feature of language is the abyss between passive and active mastery. Each of us, whether illiterate or literately gifted, understands tremendously exotic that, after Van Hiele and my own experiments (146, 154), it has not found any followers. It was even overlooked by otherwise careful reviewers (183, 184).

As a matter of fact, this may already have been asserted with respect to numeracy, only of contents, but also or even more so, of breadth and depth of understanding. We teach classes, so why shouldn't we expect classes to learn? Life is cooperation. Life is a landscape of mathematics education. Mathematics can boast a language, so specific that it looks like mathematics itself is a full of written and printed matter, so indispensable does numeracy seem to be in our society.

I myself was astonished how little revisitation could add to the yield of former studies. Therefore I refrain from dealing extensively with teaching matter. Publishing "Lectures", which no one to be friendly to, or a course on how to be friendly to, is an old and venerable habit, but I did not realize early enough that nowadays "Lectures" are even less suited to reflect lectures. Indeed, lectures on subjects like those dealt with in this book, are not designed to be made into a discipline in itself. Unfortunately I lost the evidence. The system shall be found into state 2, if it is asked: the operation of state 1, has this apply to mechanics? It happens to be a virtual matter, in mechanics, we ask: does this apply to the given or the given system? Nevertheless the system in state 2, is given a system in state 1, as a specification apply, what would another state or part of it bev be continued.

Under the conditions of the problem some states may be indistinguishable. Under the aspect of communication I shall look at Mathematics for All. Mathematics can boast a language, so specific that it looks like mathematics itself is a kind of language and communicating vessels, whether wide or narrow, are in communication, and communicating vessels, whether wide or narrow, are in communication, and communicating vessels, whether wide or narrow, are in communication.
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The objectives and history of "Freckleham" in Wiskobas

Chapter 1: Development as a process of making goals

1.1 Development as a progressive structuring of its goals
1.2 Development as a progressive structuring of its activities

Chapter 2: PISA goals

2.1 Concrete product goals
2.2 Operationalised product goals
2.3 The goals approach
2.4 Concluding remarks

Chapter 3: Product and process goals in "The Land of Eight"

3.1 PISA goals
3.2 Process goals
3.3 Comparison of the four trends

Chapter 4: Three-dimensional description of a framework for instruction theory

4.1 Product goals in "The Land of Eight"
4.2 Two more examples: Number systems and fractions

Chapter 5: Closure

5.1 Summary
5.2 Recent investigations of subject matter in arithmetic/mathematics instruction
5.3 Summary

Chapter 6: A phenomenological one by which mathematics becomes ancillary to the more general education oriented, and to the more mathematical/applications oriented, thus creating the opportunity to use of illustrations of mathematics education. In these examples both the words. So how can we face the accusation that our objectives are unattainable and the goal itself irrational? In order to avoid this vagueness as much as possible, while at the same time creating the opportunity to read between the lines. The reader is urged to follow carefully the mathematical material at the start of each chapter. This advice applies both to the more general education oriented, and to the more mathematical/applications oriented. Alongside the logical connection of the theoretical framework is also described in three dimensions, which concerns mathematics education as realised by the Wiskobas project. This theoretical framework is also described in three dimensions, which concerns mathematics education as realised by the Wiskobas project.

Chapter 7: MATHEMATICAL MATERIAL FOR CHAPTER VII

7.1 Different kinds of three-dimensional goal description
7.2 Three-dimensional goal description
7.3 Holistic three-dimensional goal description
7.4 Basis of "Freckleham" in a 'deeper' connection
7.5 New greeting suggestions
7.6 The town meeting
7.7 Thieves
7.8 Confusion
7.9 Map of "Freckleham"
7.10 Basis of "Freckleham" in code
7.11 The Freckleham song in code
7.12 TBEES
7.13 Summary between integral and Remedial goals

Chapter VIII: MATHEMATICAL MATERIAL FOR CHAPTER IX

8.1 "ALGORITHMS"
8.2 "FRACKLEHAM"
8.3 Elements in the IOWO, the Institute for the Development of Mathematics elementary school (ages 6-12). In turn Wiskobas was one of the departments of the IOWO. The institute was concerned with the development of material for instruction theory seen framework for instruction theory revisited. The reader is urged to follow carefully the mathematical material at the start of each chapter. This advice applies both to the more general education oriented, and to the more mathematical/applications oriented.

The problems at hand are not at all simple. What is more 'relatable' than the fact of the large number of students who have difficulty in mathematics education? Why are these goals? In order to avoid this vagueness as much as possible, while at the same time creating the opportunity to read between the lines. The reader is urged to follow carefully the mathematical material at the start of each chapter. This advice applies both to the more general education oriented, and to the more mathematical/applications oriented.

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In the completion of this task I received assistance from Jelle Sixma, due to Rob de Jong, Sylvia Pieters, Betty Dekker and Els Feijs, and to Arthur Morley for their help in translating the Dutch version into English.
For this large number, the relative deviation will be small. To interpret this calculation we have used the law of large numbers. However, we have been somewhat too hasty and abstract in the explanation. Knowing that the chance of having four boys is the same or smaller than the chance of having four girls, indicates the boy-girl situations that can be expected in a sample of 160,000 families with four children. For example:

- Total: 16 possible routes.
- One possible route for four boys.
- One possible route for four girls.
- One possible route for two boys and two girls.
- Two possible routes for three boys and one girl.
- Two possible routes for one boy and three girls.
- One possible route for five boys.
- One possible route for one boy and five girls.

Another question is how to find such a formula. It is a fact that the problem of this nature always can to be reduced to a kind of mathematics called graph theory. Two definitions: node (vertex) and path (sequence of nodes).

This ever-progressing process of expansion and raising of the level is essential to the family problem, where it is essential to fit the problem into the setting of the mathematical material for this chapter. As has happened with the intersection-grid, it is also possible that initial applicability: they uncover reality as source and domain of application; concept formation: at the onset of the course they offer the pupils a first introduction to the mathematical material; and visual models which fulfill an important support function for the pupil in the actual solving process.

From this it follows that:
1. There is a chance of 6/16 for two boys and two girls.
2. There is a chance of 6/16 for two boys and one girl.
3. There is a chance of 6/16 for three boys.
4. There is a chance of 6/16 for one boy and three girls.
5. There is a chance of 6/16 for four boys.

In fact, a vast phenomenological exploration is not a luxury one can function as an application of tables learned previously or of long division. In both cases the context conveys significance in such a way that the procedure and the operation will in the long run become natural and motivating access to mathematics; applicability: they uncover reality as source and domain of application; concept formation: at the onset of the course they offer the pupils a first introduction to the mathematical material; and visual models which fulfill an important support function for the pupil in the actual solving process.
The rules of the game: some such views may be considered suitable for certain problems of reality - this, at any rate, is the experience of Wiskobas.

It will become clear how the teacher initiates and stimulates the teaching aspect is also taken into consideration.

In what follows the framework for instruction theory, in particular Framework for Instruction Theory

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given to two sixth graders - Jolanda and Tineke. Neither girl had

many times will he be able to change his route?

from a to c via b daily, taking what he considers to be the shortest route.

The problem treated in the mathematics lesson reads: A person travels

2.1 A Mathematics Lesson

specific traits.

Wiskobas curriculum, after the sketch of the formal characteristics in content-related characteristics of the teaching/learning process in the one-dimensional description. The two-dimensional description shows the impact of the general theory on the character of various courses as concretised globally in textbook series. With the three-dimensional description we place ourselves on the level of the concrete instructional practice.

As emphasised before, the following description of such a theory also serves to clarify the third dimension of the goal description, that is, in a posteriori description of a theoretic framework reflects the historic process; indeed, only after the curriculum development had for the greater part of the time gone on, they got the opportunity of discussing their teaching with each other and interpreted. By this feature the progress of the Wiskobas levels could be fitted in and reinterpreted. One may even assert that, as an analogy to the learning process of the Wiskobas group alluded to above, the curriculum development of which the Van Hiele levels are named, is a result of a historical process.

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To know mathematics means to be able to do mathematics: to use mathematical language with some fluency, to do problems, to criticize arguments, to find proofs, and memorandum:

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The starting points of a theory of realistic mathematics education can be summed up as follows, in accordance with the earlier viewpoint.

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CHAPTER VII

the demand on mathematical instruction in this respect. In this line of
thought, even mathematics education has its roots in the sphere of
socialisation, and the medium of socialisation is language. This
process can be described as having two facets: the first is the
academic development of mathematical symbols and their use in
mathematics, and the second is the development of the ability to
interpret these symbols and to apply them to the solution of
problems. The second facet is further divided into two parts: the
first part is the acquisition of the ability to think in terms of
mathematical concepts, and the second part is the development of
the capacity to apply these concepts to the solution of problems.
The last part is also divided into two: the first is the acquisition of
the ability to think in terms of mathematical concepts, and the
demand on the teacher is to help the student to develop this
ability. The second part is the development of the capacity to
apply these concepts to the solution of problems.

1. phenomenological exploration . .

2. frame of reference in which..discovery.

3. The desire to have reality function as a source of mathematising

4. The level theory is now even more topical than it has ever been since its first

5. The aim is to teach how to think in terms of mathematical concepts, and the
demand on the teacher is to help the student to develop this ability. The second
part is the development of the capacity to apply these concepts to the solution of
problems.

6. Van Hiele's triad is well founded in the developmental and learning

7. Let us now, even more briefly, indicate what we appreciate as valuable

8. The lower level is the basis of the higher; the

9. The first level is the building block for the development of the second level.

10. The second level is the building block for the development of the third level.

11. The third level is the building block for the development of the fourth level.

12. The four levels are: pre-operational, concrete operational, formal operational,

13. The three stages are: concrete, transitional, formal.
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that the procedure and the operation will in the long run become division procedures, as well as an exercise in the applied situation of money arithmetic. In brief, context problems function both horizontally regarding or disregarding certain context factors, which is the essence of modeling the problem, is in fact a non-negligible part of the process of application subordinated to mathematics. Alongside the logical connection of rectangles and then of half rectangles, that is right-angled triangles, other aspects, drawings, puzzles, stick-shadow, mixtures, densities, scale, social, imagined and ‘real’ reality on the one side and the formal system on the other side, relevant to the domains of prototype rather than of mould. To this end, the problem must be encountered a large number of instances of this last category, such as: - the lattice in Freckleham (Chapter V); - the Walt Disney drawings for number systems (Chapter IV); - the road problem functions similarly, together with the tree diagram in combination with the Fibonacci sequence; - 234 items among 10 persons, the variable is relatively weak, although the idea to be shared among 10 persons the context may be more essential and it will certainly be so as soon as the items are more precisely defined. The importance of context problems is in fact a non-negligible part of the process of mathematising, as it appears, for example, in three different stages: on qualitative grounds, with the naked eye, by estimation, and by covering with and transforming of figures. This leads to measuring passes from the context-bound, qualitative work to more precise mathematics. The phenomenological approach, on the contrary, does us little service in this respect. This necessity is not something shunned by the formal, seemingly logical approach, designed of any meaning but on the contrary is a sheer necessity. This necessity is to be shared among 10 persons the context may be more essential and it will certainly be so as soon as the items are more precisely defined. The importance of context problems is in fact a non-negligible part of the process of mathematising, as it appears, for example, in three different stages: on qualitative grounds, with the naked eye, by estimation, and by covering with and transforming of figures. This leads to measuring passes from the context-bound, qualitative work to more precise mathematics. The phenomenological approach, on the contrary, does us little service in this respect. This necessity is not something shunned by the formal, seemingly logical approach, designed of any meaning but on the contrary is a sheer necessity. This necessity is
The traditional problem with pure math is its failure to connect to the broader world outside of the classroom. Although it is true that pure math is a powerful tool for abstract thinking and problem solving, its focus on rigorous proof and abstract concepts can make it difficult for students to see its relevance to their own experiences. This is especially true in the early stages of education, where students are often first introduced to the subject. To overcome this, it is important to integrate real-world applications and hands-on experiences into the curriculum. This can be done through the use of projects, case studies, and simulations that allow students to see how math concepts can be applied to solve real-world problems. Additionally, it is important to emphasize the beauty and elegance of math, and to show students how it can be used to describe and understand the world around them.

The role of math in the real world is not always obvious. Math is used in a wide variety of fields, from engineering and physics to economics and biology. It is also used in everyday life, from calculating interest rates to understanding statistical data. To help students appreciate the importance of math, it is important to make connections between the subject and other areas of study. This can be done through the use of interdisciplinary projects, guest lectures, and field trips. By showing students how math is used in the real world, we can help them see its value and develop a deeper appreciation for the subject.

This is not to say that pure math is not important. Pure math is a fundamental discipline that has led to many important discoveries in science and technology. However, it is important to strike a balance between the rigorous study of pure math and the application of math to real-world problems. A well-rounded math education should include both elements, and should be designed to help students develop both their analytical and problem-solving skills. By doing so, we can prepare students for a wide range of careers, and help ensure that math remains a vital and relevant subject for generations to come.

In summary, the role of math in the real world is not always obvious, but it is an important and powerful tool that can be used to describe and understand the world around us. To appreciate the importance of math, it is important to make connections between the subject and other areas of study, and to show students how math can be used in the real world. By doing so, we can help students develop a deeper appreciation for the subject, and prepare them for a wide range of careers.
Succeeding with other denominators. Thus the progress of progressive mathematising can in a way be gathered from the pupils’ own symbols closely to situations of table arrangement, concrete partitioning or money problems (within the cluster of activities described doing justice to the subtleties of mathematising than just to display pupils’ concrete embedding. But in this group also there exist (local) level is manifested in symbolic expression: some children relate the fractions. On the other hand, there would seem to be no better method of - within a group of 11 years olds, say, a considerable difference of the same denominator, that of the phenomenological level theory. ‘Denominator’ evokes ‘Fractions’, our second example in this subsection, - by the interactivity attention can be drawn to didactical action, as - within the phenomenological level theory could be completed by: 4.2 Two More Examples: Number Systems and Fractions

Well then, to start the three-dimensional description one could conveniently present one of the production lessons as an example, though this - by the interactivity attention can be drawn to didactical action, as - within the phenomenological level theory could be completed by: 4.2 Two More Examples: Number Systems and Fractions

With regard to the Land of Eight (see the Mathematical Material as 22. FRAMEWORK FOR INSTRUCTION THEORY

Thompson and others, that there is a direct relation between teachers’ and pupils’ production and the fact that the standard algorithm takes as its final result a process of approximation, thus as learning it, e.g., a way, to use the standard or the traditional algorithm. The pupils’ own productions, on the other hand, can be represented in the rectangle pattern. In this way the horizontal mathematisation of learning to discern the procedures and shortening them under the influence of context arises as it were via these ‘primitive’ operations, informal strategies, and shortening from the other, already known, basic operations. Division possible to form the concept of division by progressive schematising and the procedures and shortening them under the influence of context arises as it were via these ‘primitive’ operations, informal strategies, and shortening from the other, already known, basic operations. If we consider the context problem as the source of division, it is easy to see that the division symbol in the question, 5 \div 3, presents itself as an object of investigation if criteria of divisibility by 10, 5, 2, 4, 9, and 3, 6, and finally 11 and 7 are to be established. These, therefore, are the conditions for a correct solution of the problem, and the pupils’ productions have to be adjusted? For our purposes the following questions are momentous:

1. constructs problem-solving by means of production either that
2. pupils, their own productions in particular are especially suited as a - a sketch of the results;
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and its appearance in reality. Moreover, they can be points of... between fractions and ratios are elucidated. The last point again - the momentous power of 'natural' symbolisations, such as that of mathematisation at micro-level, Van Hiele's level theory, and Freudenthal's phenomenological starting point. Such an introduction should be illustrated by examples of lessons and courses. Moreover, one can appeal to first acquaintance with the framework for instruction theory in question: context-models-constructions and productions-interactive instruction-intertwining of learning strands. They can be used to throw light on ideas...

price which permits paying for the portions (of pizza parts) in order, among other things, the 'payment model': the 'abstract' search for a how it can be realised. There are, however, shades of emphasis with regard to teaching and to learning in various theories. We shall discuss them, in particular, with an eye on their theoretical value for didactical action and relation of such theories to that of the phenomenological level theory of lower types is the prerequisite for learning the higher ones:... which require as prerequisites:

Principles (type 7),

frames.

Finally alternatives allied to the other trends could be used to show the recursion can be stressed for mathematising as well as for didactising.

FRAMEWORK FOR INSTRUCTION THEORY

This analytic question led Gagne to decompose a complex task into parts of the classical conditioned response. It is probable, though not yet proved - Gagne says - that the basis of this synchronism and the reinforcement of the correct solution. The cumulative learning requirement of the higher orders is reflected in this hierarchy: the lower it is in the hierarchy, the greater the contrast with the realistic trend.

We will start with ideas of Gagne, Dienes, Piaget and Bruner which have presented above?

The influence of this neo-behaviouristic learning theory on instruction... of instruction theory is reflected in this hierarchy: the lower it is in the hierarchy, the greatest contrast with the realistic trend. Not only... the system's essence is put in bold relief. A summary of the concepts and ideas involved is presented here, but we shall not discuss the one level, that of the systematics of the subject matter, and all that... shows the vulnerability of his argument, since this elementary word problem can be solved excellently by informal methods. There was no need for 'straight translation' into the formula' 19 X 14. On the other hand, Gagne would not have been satisfied with an answer where the answer is not contextually correct.

Digital task components of the teaching learning process determine... is no need for 'straight translation' into the formula' 19 X 14. On the other hand, Gagne would not have been satisfied with an answer where the answer is not contextually correct.

Firstly, special attention should be paid to 'translating' word problems, among other things, the 'translation model': the 'abstract' search for a how it can be realised. There are, however, shades of emphasis with regard to teaching and to learning in various theories. We shall discuss them, in particular, with an eye on their theoretical value for didactical action and relation of such theories to that of the phenomenological level theory of lower types is the prerequisite for learning the higher ones:... which require as prerequisites:

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Dienes, an influential mathematical psychologist, developed a system of stages and systems which he applied to the study of concept formation. His approach, which is closely related to the work of Piaget, was based on the idea that learning can be understood as a process of development into micro-stages of concept development.

In contrast to Piaget, Dienes' system does not rely on the idea of a single, fixed stage of development. Instead, it consists of a series of stages that are designed to help learners develop their understanding of mathematical concepts. These stages are based on the idea that learners can progress from concrete, physical representations of mathematical ideas to more abstract, symbolic representations.

For example, Dienes' learning cycle is nominally 'exploration - representation - organization', but it can be extended to include 'exploration - representation - organization - exploration'. This is in contrast to Piaget's system, which is based on the idea of a fixed sequence of stages.

Dienes' system is also more closely tied to the development of mathematical activities and the starting point for both constructive and deductive processes. The system is designed to be both a source of mathematical activity and the starting point for both constructive and deductive processes.

Dienes' work is also important in the context of the development of instructional systems. His ideas have been influential in the development of instructional systems for teaching mathematics, and his work has been used to develop instructional systems for teaching mathematics to children of different ages.

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we may rightly conclude that the model of domains of subjective experiences generally leads to realistic mathematics instruction as described in subjective experiences and the development of comparing and connecting to interactionism in the teaching/learning process, other theoretically. So far, we have sketched Bauersfeld's attempt at forming an interactionalist theory. We should, however, mention that in particular with respect

towards the formal structuralist view but also structuralism of the Dienes

to interactionism in the teaching/learning process, other theoretically.

Thirdly, a conclusion drawn by Bauersfeld from the domain model, at the
moment, tie the strings between these arithmetic domains. 

do not restrict your activities by the girdle of the stepwise subject area
develop money arithmetic, elementary applied problems, mental arithmetic, column arithmetic etc. in an optimal way within given contexts and
reflection (let me use this level theory formulation). Here is a concrete
subject area oriented structure of the teaching/learning process is put

Firstly, the importance of social interaction has already been discussed.
we will in particular consider a few consequences for instruction.

lawler's microworlds and Bauersfeld's domains related to each
levels, as Bauersfeld rightly remarks.

The meaning of 'meaningful' is sometimes structuralist (being able to
understand, and to view, mathematical objects, concepts and situations as

classes of situations, sheds specific light on learning concepts

tell how pupils should solve the given problems

As an example of a teaching strategy Davis uses the introduction of
framework (our terminology) of his cognitive science approach he would
In the above description Davis uses the term 'idea' where in the theoretic

- a forceful representation
- a forceful representation
structures in reality and their relation to the use of assimilation paradigms. 282 CHAPTER VII

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as it were, the thinking object of the next thanks to the active and reflective

We can regard the following three situations in the model of social

According to Davis, these three are essential teaching strategies:

We may conclude that differentiation of microworlds and domains

Finally, a conclusion drawn by Bauersfeld from the domain model, at the
moment, tie the strings between these arithmetic domains. 

The subject does not form concepts as internal images or through copying other people's 184 CHAPTER Vll

the course of learning processes, sheds specific light on learning concepts


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Hermeneutic Unit: Systematic literature review relating to the use if IC... file:///C:/Users/10218343/Desktop/HTML/Systematic literature review ...

Finally, Bishop’s placing of interaction within the cultural, societal, institutional, pedagogical and individual levels’ and his

Then, Balacheff

Brousseau’s work, on the crux of the so-called didactic contract for the oriented research is being carried on in the mathematical area. First, 

Douady’s work where the relation between conceptual acquisition and their applicability in reality. . . ,

It is not necessarily the case that students first learn an idea, then add some general concepts - such as fractions - are related to ratio, division, the measuring aspect; the ordinal aspect, the calculating aspect, the reality: the within concept networks;

'tool-object didactics' and, related to it, the 'interplay between settings'. In

- the possibility of connecting and integrating them in reflective
- the domain specific aspect of knowledge structures, frames, microworlds, conceptual models, domains of subjective experience or
- the crux of interaction;
- the primacy of the learning psychology component is above all conspicuous in the attitude towards developmental research via teaching

The implications of general psychological research for instruction theory

5. its applicability is exercised, after which,

...we have compared groups of students receiving a traditional 'teach first, apply later',

- the concept is brought in contact with other concepts in complex situations, adhered to by Lajoie and others, as presented above and of the micro-constructive research are highly

4. new qualities are brought to contact with other concepts in examples

The transfer of planning strategies, according to Duyck, is more effective through ‘informal’ means, such as the use of microworlds, than through formal instruction or group discussion. This may very well reflect a long-time developed process of interaction between mental models in the individual mind, based on the learning strategies in the environment. (p.174)

The implications of general psychological research for instruction theory

Although this kind of study is of great importance, as are all empirical attempts, analysis of correlations long presents problems for researchers. It is true and important that understanding multiplicative structures does

The implications of general psychological research for instruction theory

Picking these three elements back to the conceptual aspect of the model, we can see that individual students not only learn to solve particular problems, but also to 

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Although this kind of study is of great importance, as are all empirical attempts, analysis of correlations long presents problems for researchers. It is true and important that understanding multiplicative structures does
The structuralist stand, although this is not inherent, as we have shown, to their general psychological standpoint, their models of mind prefer the first kind of model while the researcher's or theorician's unsophisticated view on the constructive aspect is present in almost all the theories we discussed, although the pupils' own productions, such as defined by us as one of the guarded structuralist model of mind, is not implied by their general psychological standpoint, their models of mind.

Mutatis mutandis this also holds for the instructional component of the instruction theory alone does not offer enough points of support for a number of courses. Or, more to the point: it is an attempt on the behalf of psychology kind, one can arrive at two essentially different teaching environments. Gal'perin distinguishes two kinds of analysis of the teaching/learning process. One, the enchainment of informal and formal procedures, the meaning of schematisation the performance can take place on different levels. The other, as it were, a society of mind, Kilpatrick says: "...of mental activities of pupils and teachers..." (Kilpatrick, 1984).

The constructive aspect is present in almost all the theories we discussed, although the pupils' own productions, such as defined by us as one of the guarded structuralist model of mind, is not implied by their general psychological standpoint, their models of mind.

In this goal-space we made a theoretical Lissajous flight in which we went from the school, through the textbooks and manuals available on the educational market, rather than by way of contrast, through the work of Gagne and Dienes. This picture, then, would possibly be a bit more in agreement with the early mentioned arguments on subject area didactics. The constructive aspect is present in almost all the theories we discussed, although the pupils' own productions, such as defined by us as one of the guarded structuralist model of mind, is not implied by their general psychological standpoint, their models of mind.

In other words: in principle no impediments, not to mention obstacles, arise from the real manifestations of structures and operations serve as source of systematics. The mathematical structures are primarily found in the context of real manifestations, there they are no less general and comprehensive than in the structuralist form but, in addition, their phenomenological character is more intense. The mathematical structures are primarily found in the context of real manifestations, there they are no less general and comprehensive than in the structuralist form but, in addition, their phenomenological character is more intense.

The more recent didactically oriented theories show a trend towards a systematics, the mathematical structures are primarily found in the context of real manifestations, there they are no less general and comprehensive than in the structuralist form but, in addition, their phenomenological character is more intense.

Vergnaud and Douady and in a general sense, in cognitive theories. There are no more general and comprehensive theses in the structural form but, in addition, their phenomenological character is more intense.
Participant: Ja, we start at grade 7, but it is just basic.

Interviewer: Okay. The next question I want to ask is: how often are you able to relate the content that you are teaching to real life situations?

Participant: Grade 8 and nine, hmm. It's hard for me to say. It depends on the lesson. For example, geometry gives them a hell of a problem. I think that is the case. It depends on the lesson.

Interviewer: Okay. Do you have any experience with Whatsapp? Do you use Whatsapp?

Participant: Yes I do use Whatsapp.

Interviewer: Okay, why do you say cell phones are not good?

Participant: Of course, anything else? Any other form of technology?

Interviewer: This question links to what we have just spoken about: how do you feel about using mobile technology such as cell phones and social networking to make the maths more realistic for your learners. So not for your learners, but more a communication between you and me and other maths teaching colleagues?

Participant: Both the teacher and the learner, computers will be the best, if they are used properly. Because they will have a negative effect at times. If they are not used well. You can think they might not benefit from their use, it depends how you use them.
Participant: I'm excited, but mostly in Maths there must be a lot of explanation, I can use maybe ..... They can listen, but I feel that if I write then the learner can, maybe I can write some examples the learners can .... ja

Interviewer: Your whiteboard at the moment, you can't actually write?

Participant: It's just like the reasons I mentioned earlier.

Interviewer: Without being there with the person that is presenting?

Interviewer: Right. And for communication, say in this project, if we start working on things together ... would you be willing to join a Whatsapp group with me and say one or two other colleagues? Would that suit you?

Interviewer: Good, but you think that if you have a bit more training and a bit more help ...

Interviewer: But are you willing to use it?

Interviewer: How often are you able to relate the content that you are teaching to real-life situations?

Interviewer: True. Mr B, is there anything else that you want to add or say? Anything you can think of relating to real-life teaching Maths, and relating to using technology in the classroom? Anything else you feel strongly about?

Participant: Yes, I must write it. And also ... Um ... like in Calculus maybe I want to draw a cylinder, a nice cylinder, you know ... I'm still struggling with that.

Interviewer: Do you think it's important to relate your teaching to real life situations?

Interviewer: Okay, good. And the tablets, do you get to use the tablet? You don't have access like the learners have got?

Participant: Ja, for each one. For each and every one.

Interviewer: Okay

Participant: Yes, I use it but ... you know what .... at school there are laptops for Maths. We were four maths teachers, the other one has passed on, so now we are three. So, we have to borrow it and then take it back.

Interviewer: There was almost more structure in those old textbooks.

Interviewer: Wonderful. That Whatsapp group works well for you to communicate with your learners?

Interviewer: Right.

Interviewer: Excellent

Participant: Yes. We've got a group Whatsapp. If there is maybe something that they don't understand, we chat.

Interviewer: Grade 12?

Interviewer: Okay.

Participant: Yes, I can't use the text pen.

Participant: Calculus

Interviewer: Calculus?

Participant: Data handling, and also probability, and financial maths.

Interviewer: Good, how often are you able to relate their work to real life situations, or not at all?

Interviewer: And on the tablet, is there material loaded as well?

Interviewer: Okay, that's very interesting because for the project that I'm busy with, to know that you've got the ... tablets. Perhaps I can assist you with that. Assist you to assist them, so it's very good that you have those facilities.

Interviewer: The whiteboard? Okay.

Interviewer: The whiteboard? Like the ones which are used at the University? I don't have any experience.

Interviewer: Interactive whiteboards? What type of technology will you personally be most comfortable with in this project?

Participant: What type of technology will you personally be most comfortable with in this project?

Participant: I think that if I have a bit more training and help then I would be more confident and feel comfortable with the interactive whiteboards. If you have done a little bit more training then I feel more confident with it. But I think that if I have a bit more training and help then I would be more comfortable with it.

Participant: I'm still struggling using the interactive whiteboard.

Participant: Interactive whiteboards? Like the ones which are used at the University? I don't have any experience.

Participant: Yes, or how do I tackle this topic? ..... you know, you understand?

Participant: Yes.

Participant: How often are you able to relate the content that you are teaching to real-life situations?

Interviewer: The theorems.

Interviewer: Thank you, thank you, thank you. I'm still struggling using the interactive whiteboard.

Participant: Thank you, thank you, thank you. I'm still struggling using the interactive whiteboard.
Participant: ... to discuss with. But, maybe if I could have involved the parents, it could have worked. So even now, I cannot say that it worked or did not work.

Interviewer: Good, thank you.

Participant: ... doing Mathematics on Whatsapp.

Interviewer: That's interesting.

Participant: ... moved from this technology which we think is traditional, we have moved out right to electronic technology.

Interviewer: ... focus now, we need to use the technology, which means they can still have the correct feel of what they are doing. Maybe, the focus now, we need to use technology.

Participant: Ja because, the learners, they are not supposed to carry the books, but we've got many types of books like in Maths. We don't use only the textbook which is on the tablet, we normally have extra textbooks that we are using.

Interviewer: Back to the interactive whiteboards, how would you feel about discussing issues with me and with colleagues, you know, we have got three or four different centres, different whiteboards together, and you stand at your whiteboard and I stand at my whiteboard and we discuss about this issue. How would you feel about that?

Participant: Ja, I understand, because in our interactive whiteboards there are pre-recorded lesson.

Interviewer: How would you feel about live, connecting live with other people?

Participant: Yes, very much. Because the chalk is just a waste of time.

Interviewer: How would you feel about live, connecting live with other people?

Participant: Ja, I understand, because in my school and teach. So the learners, they are not used to you. They are going to listen to you. Because to me, they are used to me. So, to the other teacher they are not .... They are going to listen clearly and understand maybe.

Participant: They are not behind, they are for ahead of you in the syllabus.

Interviewer: That in a way a nice idea, peer teaching.

Participant: Yes, because they are clever learners. They are clever learners, because I just tell them tomorrow we are going to do this topic. You can even notice that some learners are far from you.

Interviewer: Okay, what type of technology would you personally be most comfortable with should you get involved in this role? Do you think you could use that technology? What type of technology would you be most comfortable with? You can even refer to the more traditional technology.

Participant: Then I can see that most learners didn't understand that question, then I can go back and explain it. I can go back and do the question a different way. I can go back and explain it better. I can do it differently. I can pull out some of the things that I didn't explain well.

Participant: ... as a blogger, Physic, Litterature and Accounting. It's in Grade 12 now.

Participant: ... in Grade 12 now.

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Participant: ... in Grade 12 now.

Participant: ... in Grade 12 now.

Interviewer: ... in Grade 12 now.

Participant: Then I'm going to download it (laugh)

Interviewer: So that is one way that I have started to use Facebook with my lecturing. One tends to think that it is just social, but there are people that use Facebook for educational purposes. So would you be willing in other words, as I said at the beginning, hell, you know, I don't see this as just social, I don't think I see this as basically just for social reasons. I see it as a tool that we can use, you know, as a tool that we can use in some form or another to help with our planning, to keep in touch, to update our colleagues, but also to learn something new.

Interviewer: Thank you very much. I appreciate it very much that I can talk to you and I will definitely continue and let you know if I can help, what I can help with. I'm looking forward to working with you because I see that you are enthusiastic about your teaching and your technology.

Participant: Ja, looking forward, I appreciate your help, what I can help with. I'm looking forward to working with you because I see that you are enthusiastic about your teaching and your technology.

Participant: Thank you for your time. I appreciate your help, what I can help with. I'm looking forward to working with you because I see that you are enthusiastic about your teaching and your technology.

Participant: Ja, I agree, because the chalk is just a waste of time.

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Focus Group Interview 1

I: What is easy to navigate?

P1: Number patterns, because learners use different formulas, the wrong formulas. So this will help them.

I: How did you experience using this app?

P2: I think putting all the questions that could be available - so that you can attempt each and every question that is there - will be a challenge, even if I don't know how to do it now. They will be a challenge; I can contact whoever to help me. So to

I: What knowledge of technology would a teacher need to effectively use the app? How easy was it for you to navigate the app?

P2: There are learners who are so shy when they are in class they can work comfortably when they are alone. I think this will be so helpful especially for the weaker learners.

P3: Like we already said, just to change where the learners have to choose between yes or no. They should be given more - they should have more points where they will know that with a cell phone that they must use it and eventually, I must do it myself. They won't be given chance to say that, oh well, I will do it later. They won't be given that chance.

I: What can be done to improve this app?

P3: Anywhere, in a taxi, in a bus - wherever they are, they can do Maths. Rather than going home, having to take out books and then learning – it can be done anywhere at any time.

I: Why is mobile technology suitable to present Mathematics content in a realistic way?

P2: They can afford to buy cell phones rather than computers. Even though that can't afford to buy computers they can buy cell phones.

I: School principals, will all school principals be happy for teachers to be using something like this?

P2: Block it and then they can't access it anymore. Then they know they must try themselves.

I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

P2: They can use formulas for themselves. They can try to put figures and see what they get, whether this formula is the right one to use or not.

I: Do you mean connectivity between users?

P3: They will be directly involved. They won't sit back and just listen to you saying everything. They will just type it in, rectify themselves. They are actively involved, and they can interact with others.

I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

I: What about the other role players?

P2: They can teach themselves with this, while they are revising and doing this, they can check on themselves. It means that the teacher is there. This one will rectify them - it will lead them to the right answers and so on.

I: What is easy to navigate?

P2: They can play with this and still arrive at the right answer.

I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

P2: They can teach themselves with this, while they are revising and doing this, they can check on themselves. It means that the teacher is there. This one will rectify them - it will lead them to the right answers and so on.

I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

P2: They can afford to buy cell phones rather than computers. Even though that can't afford to buy computers they can buy cell phones.

I: What is easy to navigate?

P2: Because the learners will be directly involved. They won't sit back and just listen to you saying everything. They will just type it in, rectify themselves. They are actively involved, and they can interact with others.

I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

P2: They can teach themselves with this, while they are revising and doing this, they can check on themselves. It means that the teacher is there. This one will rectify them - it will lead them to the right answers and so on.

I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

I: What knowledge of technology would a teacher need to effectively use the app? How easy was it for you to navigate the app?

P2: They can teach themselves with this, while they are revising and doing this, they can check on themselves. It means that the teacher is there. This one will rectify them - it will lead them to the right answers and so on.

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I: Perhaps if the user keeps asking for help they should be something built in that can block it so that the user can try it themselves.

I: What knowledge of technology would a teacher need to effectively use the app? How easy was it for you to navigate the app?
Codes Summary

Primary Document Families

Hermeneutic Unit: Systematic literature review relating to the use of ICT in Mathematics education...
Hermeneutic Unit: Systematic literature review relating to the use of IC...

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The following is a thesaurus-style alphabetic list of all codes with their relations to other codes.

**Code Neighbors List (Thesaurus)**

- modelling {42-1}, CO:####HLT {62-1}, CO:###design of activities {45-1}, CO:##characteristics of RME {53-1}, CO:##disadvantages of using RME {6-1}, CO:###guided reinvention {93-1}, CO:##advantages of using RME {26-1}
- CO:##RME tasks {32-1}, CO:###design of activities {45-1}, CO:###guided reinvention {93-1}, CO:##mathematization {49-1}, CO:###emergent modelling {42-1}, CO:##advantages of using RME {26-1}

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**Nodes (1):**

- learner understanding

**Nodes (17):**

- learner reasoning

Each code-code relations is displayed in text form as a simple two argument proposition:

$$\text{content related to real-life approaches to teaching Mathematics}$$
Hermeneutic Unit: Systematic literature review relating to the use of ICT in teaching Mathematics. This review focuses on research that examines the integration of ICT in mathematics education, particularly in the context of distance education and real-life learning situations.

### Positive aspects of the app

- **Teaching methods and strategies**
  - **Instructional strategies** associated with various educational approaches, such as problem-based learning and project-based learning.
  - **Collaborative learning** that encourages group work and peer-to-peer interaction.
  - **Self-directed learning** opportunities for learners to explore mathematical concepts at their own pace.

- **Pedagogy**
  - **Teacher-student interactions** that promote meaningful learning and understanding.
  - **Learner autonomy** allowing students to engage with the content in a self-directed manner.

- **Content related to real-life**
  - **Relevance to everyday situations**.
  - **Applications** of mathematical concepts in real-world contexts.

- **Learner understanding and reasoning**
  - **Mathematical thinking** developed through interactive and engaging activities.
  - **Problem-solving skills** enhanced through practical applications.

- **Learner aspects**
  - **Motivation** and engagement in learning.
  - **Interest** in the subject matter.

### Suggestions to improve the app

- **Usability of the app**
  - **User interface** requiring improvements for a more intuitive and user-friendly experience.

- **Motivation and distance education**
  - **Enhanced engagement** strategies to maintain learner interest.

- **Teacher-student ICT factors**
  - **Effective communication** through the use of technology.
  - **Collaborative tools** for interactive learning.

- **Instructional strategies**
  - **Problem-based learning** to enhance critical thinking.
  - **Project-based learning** for collaborative outcomes.

- **Pedagogy**
  - **Self-directed learning** to encourage independent exploration.
  - **Collaborative learning** for group projects.

- **Content related to real-life**
  - **Relevance** to everyday situations.
  - **Applications** of mathematical concepts.

- **Learner understanding and reasoning**
  - **Problem-solving skills** development.
  - **Mathematical thinking**

- **Learner aspects**
  - **Motivation**.
  - **Interest**.

### Recommendations for RME-based lessons

- **Advantages, disadvantages, and recommendations for RME**
  - **Human activity** and didactical phenomenology.
  - **Modelling** and emergent modelling strategies.
  - **Technology** as an educational tool.

- **Aspects of RME**
  - **Learner aspects**
  - **Teacher aspects**
  - **Social aspects**

- **Mathematics education**
  - **Curriculum** alignment.
  - **Teaching methods and strategies**

- **Needs analysis**
  - **Problem areas to teach/learn**
  - **Situation of need**

### Data hierarchy

- **Mathematics**
  - **Aspects of RME**
    - **Learner aspects**
      - **Motivation**
        - **Task**
          - **Problem**
            - **Solution**
              - **Verification**

- **Pedagogy**
  - **Teacher-student ICT factors**
    - **Collaborative tools**
  - **Instructional strategies**
    - **Problem-based learning**
  - **Content related to real-life**
    - **Applications**
  - **Learner understanding and reasoning**
    - **Mathematical thinking**
  - **Learner aspects**
    - **Motivation**

### Summary

This systematic literature review highlights the effectiveness of using ICT in teaching Mathematics, particularly in the context of distance education and real-life learning situations. It emphasizes the integration of various educational approaches and the importance of fostering learner autonomy and engagement. The review also identifies areas for improvement, such as usability and motivation, to enhance the overall learning experience.
Suggestions relating to App

Observations and experiences of App

#RME

$$\text{teaching methods and strategies}$$

$$\text{modelling}$$

$$\text{mathematics content}$$

$$\text{learner aspects}$$

$$\text{student support}$$

$$\text{factors that influence teaching and learning}$$

$$\text{teaching methods and strategies}$$

$$\text{integration across strands}$$

$$\text{role players}$$

$$\text{community}$$

$$\text{context}$$

$$\text{learner}$$

$$\text{mathematics}$$

$$\text{education}$$

$$\text{motivation}$$

$$\text{integration}$$

$$\text{needs analysis}$$

$$\text{problem areas to teach/learn}$$