Screening for misconceptions and assessing these by using metacognition in a mathematics course for N2 engineering students at a Northern Cape FET college

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Abstract

This study investigated misconceptions in Algebra of students enrolled for a N2 Engineering certificate at a Further Education and Training College. The study aimed to investigate these students' misconceptions relating to Algebra which prohibited them to successfully complete their artisanship. The purpose of the research was to determine (i) the nature of these misconceptions, and (ii) the value of screencasts as a technology-enhanced learning (TEL) tool to improve instruction. The research gap that the researcher addressed related to the Mathematics misconceptions that the N2 students had, and whether these misconceptions could be adequately addressed by screencasts. The study method used was a case study design and methodology while simultaneously collecting quantitative and qualitative data. The findings encompassed the determining of main Mathematics misconceptions, producing screencasts, and assessing the screencasts with the intended target group. The study followed a four-phase strategy of testing, interviewing and analysing, and reflection based on qualitative and quantitative research strategies. During the quantitative research the research participants completed a biographical questionnaire, as well as a customised diagnostic Algebra test. The study sample comprised two groups from different trimesters at a rural FET college in the Northern Cape in Kathu, South Africa. The total population of full-time N2 Engineering students related to 113 participants. The diagnostic test comprised twelve questions from the three main Algebra concepts relating to: (i) exponents, (ii) equations, and (iii) factorisation. The same customised diagnostic test confirmed the misconceptions within the same group. Six questions from the customised diagnostic test identified the central misconceptions. The researcher consequently designed, developed, implemented and evaluated screencasts with the intended student population according to the design principles identified during the study. The six questions formed the basis of a second diagnostic test, which was used in phase three with interviews of ten research participants as part of phase 4 of the evaluation of the screencasts. At the end of the second trimester students were ask to complete a questionnaire regarding their use and perceptions of the screencasts—23 participants completed this voluntary questionnaire. At the end of the trimester ten participants were asked to explain their method of calculations during a walk-through evaluation while answering Algebra problems. The results indicated a number of misconception categories: (i) The main reason for misconceptions relating to equations was the participants' inadequate understandings of the basic concepts of multiply methods used in equations; (ii) Index laws seemed to be the biggest misconception where participants demonstrated insufficient understanding of the laws; and (iii) The participants did not comprehend the basic concepts of factorisation—they could not identify which method to use while factorising. The qualitative findings indicate that the participants found the screencasts valuable when they prepared for tests and examinations, as well as when they did not understanding a basic Mathematics concept. Access to technology in rural areas remains an obstacle to integrate technology learning tools on a large scale at the FET College.

Key words: Misconceptions; mathematics; case study research; metacognition strategies; screen-cast; student profile; Algebra; blended learning; technology-enhanced learning.

Opsomming

Hierdie studie bestudeer die miskonsepsies in Algebra van studente wat ingeskryf is die N2 ingenieurs sertifikaat op 'n Verdere Onderwys en Opleiding (VOO) Kollege. Die studie is gemik om die studente se miskonsepsies rakende Algebra wat hulle verhoed om hulle vakleerlingskap te voltooi. Die doel van die navorsing was om die volgende te bepaal (i) die aard van die miskonsepsies en (ii) die waarde van skermsteun (screencasts) as 'n tegnologiese gesteunde leer (TEL) hulpmiddel om onderrig te verbeter. Die navorsings gaping wat die navorser aanspreek is in verband met wiskundige miskonsepsies wat die N2 studente gehad het en of hierdie miskonsepsies genoegsaam aangespreek word deur skermsteun (screencasts). Die studie metode wat gebruik was 'n gevalle studie en die metodologie was kwantitatief en kwalitatief wat gelyktydig ingesamel was. Die bevindinge vervat die bepaling van die Wiskundige miskonsepsies, die vervaardiging van skermsteun (screencasts) en die beoordeling van die skermsteun (screencasts) deur die beoogde teikengroep. Die studie het 'n vier fase strategie van toetsing, onderhoude, analisering en refleksie gebaseer op kwalitatiewe en kwantitatiewe navorsings strategieë gevolg. Gedurende die kwantitatiewe navorsing het die navorsings deelnemers 'n biografiese vraelys asook 'n aangepaste diagnostiese Algebra toets voltooi. Die studie voorbeeld het bestaan uit twee groepe wat in verskillende trimesters aan die Noordkaap Landelike VOO Kollege in Kathu, Suid Afrika gestudeer het. Die totale populasie van die voltydse N2 Ingenieurs groep was 113 deelnemers. Die diagnostiese toetse bestaan uit twaalf vrae vanuit die drie hoof algebraïese konsepte naamlik: (i) eksponente, (ii) vergelykings en (iii) faktorisering. Dieselfde aangepaste diagnostiese toets het die miskonsepsies in die groep bevestig. Ses vrae uit die aangepaste diagnostiese toets het die sentrale miskonsepsies geïdentifiseer. Die navorser het gevolglik skermsteun (screencasts) ontwerp, ontwikkel geïmplementeer en geëvalueer met die hulp van die studente populasie volgens die ontwerp beginsels wat in die studie geïdentifiseer was. Die ses vrae vorm die basis van die tweede diagnostiese toets wat deel uitgemaak het van fase drie en onderhoude met tien deelnemers as fase vier, die evaluasie van die skermsteun (screencasts). Teen die einde van die tweede trimester was die studente gevra om 'n vraelys te voltooi ten opsigte van die gebruik en hul persepsie van die skermsteun (screencasts) ---23 deelnemers het die vraelys vrywillig voltooi. Teen die einde van die trimester is tien deelnemer gevra om hul metode van berekenings stap vir stap te verduidelik. Die resultate het 'n aantal miskonsepsie kategorieë getoon: (i) Die hoof rede vir die miskonsepsies rakende vergelykings was die deelnemers se ontoereikende begrip van die basiese konsepte van vermenigvuldigings metodes wat in vergelykings gebruik word; (ii) Met indeks wette was daar blykbaar die grootste miskonsepsies waar deelnemers onvoldoende begrip gedemonstreer het in die verstaan van die wette; en (iii) Die deelnemers het nie die basiese konsepte van faktorisering begryp nie – hulle kon nie die korrekte metode identifiseer met faktorisering nie. Die kwalitatiewe bevindinge toon dat die deelnemers skermsteun (screencasts) waardevol gevind het wanneer hulle vir toetse en eksamens voor berei, asook wanneer hulle nie 'n goeie begrip gehad het van basiese Wiskundige konsepte. Toegang tot tegnologie in die landelike areas bly 'n struikelblok om tegnologiese leer hulpmiddels te integreer op 'n groot skaal in VOO kollege.

Sleutelwoorde: wanopvattings; Wiskunde; Algebra; gevalle studie navorsings, metakognisie, screencast (skermsteun); studenteprofiel; gemengde leer; tegnologie-ondersteunde leer.

Declaration of Own Work

DECLARATION

I the undersigned, hereby declare that the work contained in this 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

24/11/14
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I hereby declare that I have linguistically edited the dissertation submitted by Mrs Susan Cecilia Beukes for the MEd degree.

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List of Acronyms

ANA	Annual National Assessment
CEO	Chief Executive Officer
DHET	Department of Higher Education and Training
FET	Further Education Training
FETC	Further Education Training Certificate
HEI	Higher Education Institution
ICT	Information and Communication Technology
N	Nated
N	Number of student
NCR	Northern Cape Rural
NCV	National Certificate Vocational
NMMU	Nelson Mandela Metropolitan University
NWU	North West University
ODL	Open Distance Learning
PBL	Problem-based learning
PC	Personal Computer
SA	South Africa
SPSS	Statistical Package for Social Scientists
TEL	Technology-enhanced learning
TTB	Technical Test Battery
WEF	World Economic Forum

Chapter One

Orientation to the use of screencasts in an N2 Mathematics course

1.1 Context of the study

Mathematics is regarded as "the science of numbers and of shapes, including Algebra, Geometry, and Arithmetic" (Longman, 2009, p. 1078). Studying mathematics is different from other disciplines or curricula. Some students have a problem relating to Mathematics (Pieterse, 2014). For some reason the thoughts and concepts of Mathematics just do not come together for some students. A possible reason for complications in Mathematics may be that the approximate number system does not progress and develop at the same pace and rate as all the learners, leaving the slow student little opportunity to obtain cognitive demonstrations of numbers that form the foundation for Mathematics. Therefore students regularly have problems in achieving good Mathematics results (Allen, 2007; Foster, 2007; Swedosh, 1998). Students do not enter the Mathematics class as empty pages or as blank slates (Swan, 2000). The students come to class with pre or prior knowledge of Mathematics, as well as a variety of Mathematical misconceptions (Booth & Paré-Blagoev, 2011; Gooding & Metz, 2011).

The development of skilled Mathematicians in South Africa is a growing concern (Welder, 2012). After years of inadequate performances in World Economic Forum (WEF) education rankings, South Africa hit the lowest point in an international measure of the value of Mathematics and Science education (Kajander & Lovric, 2009). The recently published WEF Global Information Technology Report 2013 positions South Africa's Mathematics and Science education second last in the world and graded the position of the education system 140 out of 144 nations (Lovemore, 2013). As far as learning outcomes go, South Africa has a below average education system when compared to all middle-income nations, that take part in cross-national assessments of educational achievement. South Africa performed worse than other low-income African nations (Spaull, 2013). According to the report of the Global Information Technology Report of 2014 South Africa was placed last out of 148 countries of the quality of Mathematics and Science teaching and learning (Kachapova & Kachapov, 2012).

The concerns with Mathematics education in South Africa do not originate at grade twelve level, as each year of schooling builds on the previous year to form a solid foundation (Bamberger & Schultz-Ferrell, 2010). The majority of South African learners are significantly weaker than their international counterparts in terms of advancing through the syllabus and successfully reaching the outcomes, and in general, they have not reached a host of standard numeracy and literacy objectives and goals (Kazemi & Ghoraishi, 2012). Therefore, preparation for Mathematics, especially Algebra in the middle grades, is essential to achievement in Mathematics (Bush, 2011; Egodawatte, 2011). By neglecting to achieve quality delivery, the education system is effective to only a percentage of the students who are able to get admission to private or previous Model-C institutions (Spaull, 2013). For the majority of learners, quality education remains short-circuited as in the past (Burkhardt, 2006; Spaull, 2013).

Since Algebra is a stepping stone to advance in Mathematics, education institutions should become proactive by placing more value on Algebra. To be skilled in Algebra has become a gateway to succeeding in high school and for being prepared for college or university and the place of work (Bush, 2011; Sylvan, 2011). Algebra is difficult, therefore instead of being a gateway, it can easily be a barrier that obstructs students' paths (Stacey, 2011).

Mathematics, especially Algebra is therefore important to higher education, particularly in technical fields like engineering (Lucariello, Tine, & Ganley, 2014b; Miller, 2014; Powell & Hall, 2002). The Department of Basic Education (DBE) provides support to post-school education and training like universities, universities of technology and colleges to improve their results. In South Africa, Further Education Training (FET) colleges are important to national development. The public FET colleges are fundamental to Government's plans of skilling and reskilling the youth and adults (Botha, Kiley, Truman, & Tshilongamulenzhe, 2013). FET courses are occupational by nature, meaning that students obtain education and training with the understanding that it leads towards particular employment.

Engineering artisans and students who want to improve or complete their technical qualifications have to complete the Nated-courses which start at N1, progressing through to N6. These curricula are delivered with the support of Department of Higher Education and Training (DHET) and are quality assured by Umalusi, the Council for Quality Assurance for General and Further Education and Training relating to the theoretical parts of the course (Botha et al., 2013; Umalusi, 2013). N1 to N3 engineering studies take one year to complete, and for N4-N6 Engineering Studies require an additional year. Mathematics is compulsory on levels N1-N4, and is optional for N5-N6. Those wanting to work to a career in engineering or trade have to fulfil the requirements for Mathematics (Bush & Karp, 2013). N1-N4 electrical and mechanical courses comprise four compulsory subjects. Electrical Engineering students have to complete Industrial Electronics, Electro-Technics, Engineering Science and Mathematics while Mechanical Engineering students have to complete Engineering Science, Mechanical Drawings, Mathematics and the Trade subject. The trade subject can be Diesel, Fitting and Machinery, or Plater's theory. Mathematics is regarded as one of the difficult subjects at the College. If new Mathematics concepts do not fit in with the students' familiar outline of thinking, the concept is changed to fit their current patterns of thinking (Lucariello, 2009; Lucariello, 2011; Luneta & Makonye, 2010)(Lucariello, 2009; Lucariello, 2011; Luneta & Makonye, 2010)(Lucariello, 2009; Lucariello, 2011; Luneta & Makonye, 2010). This is when misconceptions are formed and strengthened. The student builds explanations and solves problems according to incorrect cognitive thinking. Such Mathematics misconceptions have huge implications on teaching and learning (Yazdani, 2006).

A possible solution for correcting common misconceptions in Mathematics is to use technology in blended learning. Blended learning offers a means to integrate the "best of both worlds," to build and form an appealing situation for teaching and learning. By subjecting our students to different ways of learning, we are preparing and training them to be self-motivated students beyond the borders of the classroom. Education is all about teaching and learning in methods that are most advantageous to our students (Booth & Koedinger, 2008b). Blended learning uses technology to not merely supplement, but change and better education (Welder, 2012).

1.2 Literature study

Literature searches were conducted on EBSCOhost, ERIC, Academic Search Premier, Google, and Google Scholar databases, catalogues of South African and international university libraries, Sabinet, as well as the World Wide Web. The following key words were used: misconceptions, Mathematics, Algebra, screencasting, learner profile, teaching and learning, case study, mixed method research, metacognitive skills, blended learning, and pedagogy. From these searches, the following section provides a brief overview of the literature discussed during this study.

1.2.1. Blended learning

There has been a paradigm shift from face-to-face learning to online or hybrid learning (Grossman, 1996). After generations of teaching all Mathematics students at the same pace in classes, current Mathematics educators practise a practical, technology-aided substitution, blended learning approach. Blended learning can be defined as a blend of traditional teaching experiences with online and technology experiences of which the purpose is to complement the best aspects of both options in order to assist and support the students' learning (McIntyre, 2007b). Blended learning can be used to meet the requirements of students' diversity relating to various generations, numerous personalities and learning styles (Xiaobao, 2006). Blended learning indicates that different methods, notions, and didactical principles, usually used in isolation, are now connected flexibly to suit the needs of the student for a complete education involvement. In other words, blended learning should be considered as a fundamental reform and design of the instructional paradigm. It entails a shift from educator-centred teaching to student-centred learning, increases communication and interface between student-educator, student-student, student-subject matter, and student-external sources (Devichi & Munier, 2013). The educator roles are changing from holders of information to facilitators where different methods and styles of teaching are being used.

The use of blended teaching methods could lead to a higher-level of reasoning, a deeper approval of an educational community and an intensification in self-regulated skills (Bambico, 2002). There is some indication that blended learning will have a positive influence on overall student results (Bambico, 2002). When an educator takes the time to combine constructed blended teaching methods well, keeping in mind students' requirements and needs, the final results could be equally successful, or more successful and useful for most students used during direct traditional teaching. An advantage of blended learning is that students understand learning in ways which they are comfortable in, while being confronted to experience and study in new ways (Xiaobao, 2006). There are many reasons for using bended learning (Schnepper & McCoy, 2013). These include:

- making education more available and reachable, likable, applicable and appropriate
- offering more flexible studying and learning chances
- decreasing the time spent on traditional education actions
- mixing practitioner-centred skills with classroom-centred education
- using databases that are cheap to replicate or use with huge amount of students
- discovering new methods and styles to utilise during learning and teaching.

Integrating technological tools provides a range of possibilities. Students of today expect schools, colleges and universities to be as technology rich as the globe around them. The students play video games, connect with friends through different social media; therefore they want that same kind of situation in the classroom (Rushton, 2014). With the advances in the use of technology in education, educational institutions are forced to reconsider the incorporation of technology in teaching and learning. The future of learning involves customisation and personalisation of learning materials. Screencasts can be seen as an effective component for blended learning that personalises and customises learning and teaching for different students. Screencasts as technology are more and more generally used to support students in Mathematics (Russell, O'Dwyer, & Mirinda, 2009). It appears that screencasts offer procedural knowledge rather than any form of mathematical knowledge and yet screencasts have the potential to do so much more. In the end, educators are confronted with students who come to them with not the same levels of metacognitive skills. The different levels of metacognition can cause different misconceptions in Mathematics (Dawkins, 2006; Van der Walt & Maree, 2007; Yoong, 2002).

1.2.2 Metacognition of Mathematics

Metacognition is generally defined as reasoning about thinking (Blakey & Spence, 2008; Cao & Nietfeld, 2007). Metacognition is the action of observing and monitoring one's reasoning and understanding (Onu, Eskay, Igbo, Obiyo, & Agbo, 2012b; Young & Fry, 2008). In the classroom background, metacognitive knowledge lets students become aware of what they identify and what they do not identify about a particular focus area or topic. This understanding gives students a starting point for planning and dealing with allocating time. Metacognition is not just a private internal activity, it is synonymous with wanting to communicate, explain and justify the way you think to both yourself and others. The kind of discourse suggested above is necessary to reveal knowledge, misconceptions and learning strategies(Egodawatte, 2009). The use of different approaches and strategies reflects metacognitive knowledge and skills.

The metacognitive approach in Mathematics is one of the instructional interventions that could be described as strategies or methods students use to explain and solve mathematical difficulties (Cao & Nietfeld, 2007), and it includes the following three aspects: understanding our thought process, restraint or self-regulation, and beliefs and instinct. The students must divide their time between (i) identifying the problem, (ii) planning of strategy (iii) making decisions, and (iv) implementing the correct steps (Johnson & Naresh, 2011; Schoenfeld, 1987). Metacognition increases the significance of students' studying, and establishes a Mathematics culture. It would inspire students to make Mathematics a vital part of their normal lives, promoting the opportunity of students getting connections between Mathematics theories in different circumstances, and students working out the details of Mathematics together (Yoong, 2002).

When using metacognition in Mathematics there are basic steps to consider while teaching students: (i) confirm your hypothesis, (ii) know your strengths and limitations, and (ii) recognise when to adapt. Teaching using metacognitive strategies will improve learning and teaching (Lovett, 2008; Onu et al., 2012b).

Misconceptions are but one side of incorrect and inaccurate thinking. Mathematics educators should use varied ways of solving and answering problems so that students will not have the misconception that there is a fixed method or technique in solving problems. Educators should use several approaches and different methods in confronting specific Mathematics problems (Nool, 2012b). This will help to erase the students' incorrect notion that there is only one method to solve some problems. The educators can start using technology in the learning environment, it makes learning more student orientated and less educator orientated.

1.2.3 Screencasts

A screencast is a digital recording of a computer screen in which audio narration describes and explains the information on the screen (Jordan, Loch, Lowe, Mestel, & Wilkins, 2012a; Udell, 2005). Screencasts offers a "look over my shoulder" outcome equivalent to one-on-one teaching. They can be retrieved when and where they are useful (Raftery, 2011) and this technology allows the student and educator to interact easily and simply over any distance.

For Mathematics education, the production of screencasts allows the real-time recording of handwritten step-by-step explanations of problems including expert mathematical representation (Jordan et al., 2012a; Steinle, Gvozdenko, Price, Stacey, & Pierce, 2009). The student support ranges from small and brief "bite-sized learning chunks" which is used to support a theory, or emphasise a procedure already taught (Henderson, 2010). Students feel that the screencasts help their understanding of mathematical techniques and different procedures (Wilkes, 2012a).

Screencasts may be instrumental in addressing the different learning styles of diverse students (Kanter, 2007; Wakefield, Frawley, Dyson, Tyler, & Litchfield, 2011) and demonstrating procedural knowledge (Feinstein, 2010; Williams, 2010). Therefore screencasting can be used in various ways in teaching and learning, for instance, to offer an in-depth description of difficult concepts and procedures, to explain and prove mathematical equations, to review part of a lecture that student may benefit from for examination or tests (Henderson, 2010).

The research gap of this study relates to the misconceptions that specifically N2 students have relating to Mathematics especially Algebra, and whether these misconceptions could be addressed by screencasts as a technology solution to extend the role of the educator. The assumption is that there may be specific misconceptions that impact negatively on their understanding of Mathematics. This study investigated whether the N2 Mathematics students have misconceptions of Algebra, and if confirmed, what the nature of these incorrect assumptions were.

1.3 Purpose of the study

The aim of the study is to gain an in-depth understanding of N2 Mathematics students' misconceptions relating to Algebra. The research questions for this study are:

- What are the N2 students' misconceptions relating Algebra?
- To what extent could students' misconceptions be addresses by using screencasts in order to increase their metacognitive skills when learning Mathematics concepts?

1.4 Research design and methodology

A case study can be defined as an exploration of a bounded system or a particular or multiple case, over a period of time through detailed, in-depth data collection involving numerous sources of information (De Vos, Strydom, Fouche, & Delport, 2011, p. 320). The boundaries of this case study will be between trimester one and two in 2013, the social group will be the 113 of N2 Mathematics students attending the fulltime classes at the NCRFET College, Kathu Campus in the Northern Cape of South Africa. The evidence will be collected from an open- and closed-ended demographic questionnaire, a diagnostic Mathematics test and lastly a few interviews. The study described the testing for misconceptions in algebra, producing screencasts of the misconceptions and evaluating the screencasts. During each trimester four phases were followed. The study used a combined and consecutive use of quantitative and qualitative research methods for testing misconceptions and evaluating the screencasts.

At the start of a study, researchers decide about philosophical assumptions that support their research. Burrel and Morgan (2005) describe four philosophical assumptions: ontology, epistemology, human nature and methodology. The ontology of research relates to the core of the facts under study. Epistemology wants to find out how knowledge and skills can be learned and developed and how reality can be originated. Human nature wants to find out if we are creations of our circumstances or whether we form our environments. The methodological assumption focuses on analysis of the methods used for gaining the data. Therefore it is the approach, method or strategy and use of particular approaches. Linking the carefully selected methods and getting the preferred outcome. This study aimed to produce better instructional practices and therefore relates to the constructivist paradigm and what approaches of investigation are appropriate for finding answers. The study made use of pragmatist methodologies of mixed methods (Wang & Hannafin, 2005b) in order to provide design principles for the best set of practices (Engelhart, 1997) relating to N2-level Mathematics students' misconceptions about Algebra.

Quantitative and qualitative research methods were used. Quantitative research is a formal, objective, systematic process in which numerical data are used to obtain information about the world. Quantitative research method is used to describe variables, to examine relationships among variables and to determine cause-and-effect interactions between variables (Burns & Grove, 2005; De Vos et al., 2011).

Qualitative research can be explained as a method rather than a specific design or set of procedures (Wellman, Kruger, & Mitchell, 2005). The researchers have a tendency to gather the information and facts in the field themselves at the site where participants or students encounter the problem. The researchers then construct designs, by categorising and classifying the information into progressively more conceptual and theoretical elements of data (Creswell, 2009).

The population for the study was engineering students enrolled for the N2 National certificate. The researcher used a purposive sample of voluntary students enrolled for the course to take part in the study. Students who did not want to participate in the study completed the assignments together with the other students, but their input was excluded from the study.

In this study three methods of data collecting were used: (i) a diagnostic test, (ii) a questionnaire, and (iii) interviews with the research participants. Descriptive data analysis was used in accordance with guidelines and assistance from the Statistical Consultation Services of the North West University (Potchefstroom Campus) with the Statistical Package for Social Scientists (SPSS, 2012) and Atlas.ti™ Atlas.ti (2013), a computer-based qualitative analysis program.

The researcher requested the students' participation in the study. Students were informed that their participation would be appreciated, but participation was voluntary. Students had the right to withdraw from the research at any time, without fear of being penalised. Their responses were confidential and any publication as an outcome of the survey shall not identify any individual in any way. Students not taking part in the study continued with contact sessions as usual, but the researcher did not use their responses as data in the study. Written informed consent was obtained from all the participants and ethics approval for the study was obtained from the Ethics Committee of the North-West University, Potchefstroom campus.

1.5 Preliminary structure and chapter division

Chapter 1	Orientation to the use of screencasts in an N2 Mathematics course
Chapter 2	Reviewing of literature
Chapter 3	Case study research design and methodology
Chapter 4	Phase 1 analyses of integrated qualitative and quantitative data
Chapter 5	Development, implementation and evaluation of a screencast for N2 Mathematics Education according to phase 1 findings
Chapter 6	Synthesis, conclusion and reflections on the use of case study for developing a technology tool for N2 Mathematics.

Chapter Two

Reviewing of literature

2.1 Introduction

Mathematics is one of the building blocks in people's lives. As a toddler you learn to add, subtract, multiply and divide. These significant building blocks constitute the ground work and preparation of Algebra later in life. All Mathematics areas use the basic concepts of Algebra (McIntyre, 2007b). Problems that learner experience with Algebra stem from experiences long before students take their first Algebra lesson. Elementary school educators may not know how the subtleties of the arithmetic content they explain can intensely, and sometimes negatively, influence their students' ability to conquer Algebra (Bush & Karp, 2013; Welder, 2012). The educators of elementary schools may not be teaching formal Algebra, but they are in charge of constructing the foundation or basis for Algebra (Campell & Prew, 2014). According to the constructivist approach new data is built on recent attained data, and therefore the establishing of fundamental Algebraic understandings promotes the founding of important learning opportunities as students expand concepts to more complex concepts. Campell and Prew (2014) suggested that South African educators in secondary levels need additional training in order to teach basic Mathematics. They also need to learn how to identify students who have insufficient basic mathematical skills. Algebra is, in short, the opportunity and access to accomplishment in the 21st century (Cangelosi, Olson, Madrid, Cooper, & Hartter, 2011). When students make the change from real arithmetic to the symbolic Algebra terminology, they develop theoretical and conceptual reasoning skills necessary to perform well in Mathematics and Science.

Additionally, students and educators should balance procedural and conceptual understanding of Mathematics (Bush & Karp, 2013). Conceptual learning in Mathematics emphasises and connects concepts towards the generalisation of ideas (Booth & Koedinger, 2008b). Conceptual knowledge is information that is rich in association. Procedures focus on efficiency skills and step-by-step techniques, procedures and sequencing of events (Grevholm, 2008). Procedural learning must be grounded on ideas and thoughts of concepts that have been learnt previously (Bush, 2011; Fensterwald, 2012; Kajander & Holm, 2013). Pessimistically, procedures and steps are sometimes taught without effectively linking the steps to Mathematical concepts and procedures. The students learn the steps without knowing why they are following the steps (Cangelosi et al., 2011). Conceptual and procedural learning are essential, but procedural and conceptual learning should be taught together in order to connect the content relating to real life situations which the student is familiar to (Booth & Koedinger, 2008b). Students seem unable to link real-life content with the application thereof, despite repeating the same content on many occasions, for example, focussing on specific content areas, and the use of a tutor, student support, or allocating different educators with different instructional styles.

Errors developing from such misunderstandings may direct a mutual set of misconceptions that affect the learning of all Mathematics content areas. Through past and new research, educators recognise extensive misconceptions and challenges that students have to confront while learning Algebra (Allan, 2007; Egodawatte, 2011; Swedosh, 1998; Welder, 2012).

2.2 Misconceptions

A misconception refers to a student's difficulty in interpreting and understanding of main Algebraic concepts (Bush, 2011). Misconceptions are related to the understanding of procedures and conceptual knowledge (Allen, 2007; Booth & Koedinger, 2008b) and takes place when an individual (student) believes in a concept that is subjectively flawed. The challenging issue concerning misconceptions is that many students have difficulty in giving up the misconceptions because the incorrect concepts could be deeply rooted in their mental maps (Xiaobao, 2006). Some students do not like to be pointed out as incorrect and will continue hang on to the misconception in the face of evidence to the contrary (Booth & Paré-Blagoev, 2011). Misconception can also be seen as the foundation of insufficient understanding or in many cases the misapplication or misuse of a rule or mathematical generalisation (Allen, 2007). Students create rules to clarify the patterns and examples they see around them. Misconceptions do not exist independently, but are reliant on the existing conceptual structure in the mind of the student (Olivier, 1989). Errors and misconceptions are seen as the result of students' efforts to model their individual concepts, and these misconceptions are intelligent structures based on incorrect or lacking pre-knowledge (Olivier, 1989).

2.2.1 Causes of misconceptions

Misconceptions result from pre-knowledge and encounters with numbers, figures and formulas in their real lives. Some misconceptions can simply be owing to students' negligence, slips, insufficient learning and poor recollection of Mathematics formulas, concepts and steps (Lucariello, 2011; Spooner, 2002). Students' understanding of the subject can be illogical or misinformed due to misconceptions (Lucariello, 2011). Misconceptions are caused by conceptual change, where new material and concepts clash with students' earlier or pre-knowledge, usually picked up on the basis of daily practices and experiences (Booth & Paré-Blagoev, 2011; Vosniadou & Verschaffel, 2004).

The study of Luneta and Makonye (2010) show that the majority of the misconceptions were directly related to knowledge gaps in basic Algebra, and misconceptions in calculus were linked to students' over dependency on procedural information which had no conceptual foundation. According to Radatz (1979), various causes of misconceptions in Mathematics can be identified by investigating the instruments used in gaining, handling, thinking, and replicating the data in Mathematics assignments. He classified four misconception categories. Misconceptions due to (i) handling iconic symbols and signs, (ii) deficiencies of mastery essential skills, proofs, and notions, (iii) incorrect links or rigidity of thinking leading to insufficient flexibility in interpreting and converting new data and the inhibition of handling new data, and (iv) the application of unrelated and wrong rules or approaches.

Barrera *et al.* (2004) reported that misconceptions caused by a lack of meaning can be distinguished into three different periods: Algebra misconceptions beginning in arithmetic, technical and practical errors, and misconceptions due to the arithmetic language (basic errors). Misconceptions could also originate from textbooks, language and educators teaching methods.

2.2.1.1 Misconceptions caused by textbooks

Textbooks may also contribute to establishing misconceptions. Mathematics textbooks are important parts of our everyday lives as Mathematicians and educators. Students use Mathematics textbooks for revision, homework questions, study for examinations and prepare for test. Lecturers and teachers use them for lesson preparation. Textbooks form the backbone of the schooling experience of Mathematics (Kajander & Lovric, 2009). However, if the content contains defective knowledge or data, the outcomes could be significant for students (Deshmukh & Deshmukh, 2010).

During the evaluation of textbooks' contribution to misconceptions, Kajander and Lovric (2009) found that some textbooks were acceptable and suitable, although not regarded highly. Three textbooks that have been used in the USA were rated as insufficient due to the deficiencies in the content. The same report claims that no single textbook appropriates for building on students' thoughts and concepts about Algebra or to assist them to overcome their misconceptions or replace lost or misplaced data. Textbooks should be carefully selected in order to assist students' learning and to avoid the misconceptions (Deshmukh & Deshmukh, 2010).

2.2.1.2 Misconceptions caused by educators

Misconceptions can also be created during teaching and learning when educators explain concepts (Bamberger & Schultz-Ferrell, 2010). Educators' content and concept knowledge of Mathematics can create misconceptions. In an effort to make learning easier, educators may contribute to the misconceptions, for example in an effort to make difficult procedures or method easier an educator may say something that could contribute to a misconception which is hard to change. Thinking that addition always means put together or join may make it difficult for students to solve a variety of addition problems if the phrase sum of is used. An educator's choice of words is important and can be a source of misunderstanding; an obstacle for students, and cause misconceptions (Devichi & Munier, 2013).

In a study of determining educators misconceptions, I used interviews as the research instrument, six schools were used, four male and four female teachers from each. Six were Science and six Mathematics teachers. Mathematics courses were offered to educators who wished to improve their Mathematics knowledge. Many of the educators who participated in the courses were currently teaching

Mathematics in schools. They attended vacation programmes that covered the first-year modules at the Nelson Mandela Metropolitan University (NMMU) (Wetzel, 2008).

A student accepts an educator's procedures and viewpoints without investigating, from whole-hearted faith and trust in the educator. Educators' errors and misconceptions deserve consideration to avoid transfer to students in school and further education institutions (Ryan & McCrae, 2005). Rowntree (2008) maintains that one has to deal with the misconceptions that educators create before one assists students to overcome their misconceptions.

Bambico (2002) found that some of the misconceptions the educators created were due to insufficient content knowledge, others were indicative of serious misconceptions. Thus, educators, like students, maintain some difficulties and misconceptions. In the study by Bambico, he asked the question: There are six pencils and ball pens in a box. If the ratio of pencils to the ball pens is 1:2, how many ball pens are there? Seventy per cent of the educators supplied an incorrect response. Educators also have misconceptions relating to mass measurement, area and perimeter. The educators also have inadequate knowledge on factorising and on using the four basic operations (Bambico, 2002; Wagner-Welsh, 2008).

2.2.1.3 Misconceptions caused by language

In order for students to know and recognise Algebra, it is essential that educators use correct, consistent terminology. It is also important that educators present ideas in different ways, using correct Mathematics vocabulary for students to understand and remember what they are teaching (Powell, 2012). Some words have many different meanings in the English language and the Mathematics word can easily be mistaken (Deshmukh & Deshmukh, 2010). The key obstacle in word problems was interpreting them from normal language to Algebraic language. Students used predicting or trial and error techniques in solving Mathematics problems (Egodawatte, 2011). For example, the term opposite is used broadly in education while the mathematical phrase, additive inverse, is used sparingly and not very often, if at all. Students are subjected to the term opposite in circumstances such as, the opposite of a number is just the number on the opposite side of zero on the number line, or "the opposite of b is -b." If students are not happy with the term additive inverse, they might not fully create perception about negativity. For instance, they might not be aware of that -b could represent either a positive or negative number, or that -2^2 is the opposite (additive inverse) of 2^2. In addition, limited use of the term additive inverse might affect students making links and relations to other types of inverses, such as multiplicative inverse and function inverse (Egodawatte, 2011).

Makonye (2011) indicates in a South African study that students had many misinterpretations and misperceptions of several terms such as function, co-ordinate, tangent, limit, secant, distance, midpoint, equation of line, variable, gradient, maximum and minimum point and point of inflexion. Students held conflicting meanings of these terms, which led them to incorrectly understand the questions. Importantly the students in this study were not fluent in English, their second language. When Mathematics is taught in English, students not only have to study English, but they also have to study English terminology used in Mathematics. This could lead to misconceptions due to the deficiency of their interpretation of English (Barke, Hazari, & Yitbarek, 2009; Goolamally & Ahmad, 2010). Examples of language difficulty (De Wet & Trollope, 1995):

- Common specifies magnitude
- Full stops specify multiplication
- An expression is not look on a face
- An argument is not something you lose
- A complex is not something you stay in.

2.2.2 Removing of misconceptions

Educators can be surprised to learn that, regardless of their best attempts students do not grasp essential ideas covered during classes. Even some of the top-performing students give the correct answers, but are only using certain learned words. When questioned more carefully, these students disclose their failure to completely understand the fundamental concepts. By acquiring the skill how to correct Mathematics students' misconceptions, rather than their errors, educators have the opportunity to target additional students and improve those students' conceptual knowledge of the issue or subject (Alkhalifa, 2006; Holmes, Miedema, Nieuwkoop, & Haugen, 2013; Luneta & Makonye, 2010). The identification of misconceptions in students' understanding is an important part of the process of moving forward. The focus should be on learning and not on instruction; on students' conceptual growth and expansion during teaching (Holmes et al., 2013), using counter-examples (Kachapova & Kachapov, 2012).

Researchers in the domains of cognitive development and cognitive science have identified an instructional technique: the use of worked example with self-explanation prompts (Booth & Paré-Blagoev, 2011). When studying worked examples, students should be encouraged to explain them. Self-explanation enables students by mixing new facts with what they already know, and influences students to make their new knowledge explicit.

Repeating lessons and providing additional exercises alone do not eradicate the problem. Students should be made aware of their misconceptions, as well as shown how to correct them. It is important to recognise misconceptions and engage with students in discussions on these misconceptions in order to clear them up (Liang & Wood, 2005; Swedosh, 1998; Wetzel, 2008). Altering the theoretical framework and basis of students' knowledge is one of the keys aims in fixing and solving Mathematics misconceptions (Allen, 2007).

Jordaan (2005) suggests that the educators should move away from traditional teaching (talk-and-chalk methods) to a constructivist approach which allows students to create their own meanings and develop their own understanding. By using alternative instructional strategies, educators could lead students to adjust or change misconceptions in order to improve the learning of new concepts and theories (Lucariello, 2011). Educators' aims should be to teach with the emphasis and importance placed on the understanding of a rule rather than just remembering the rule (Swedosh, 1998). Swedosh and Clark (1998) posit that the conflict teaching method significantly decreases Mathematics misconceptions. The conflict teaching approach is based on Piaget's notion of cognitive conflict, in which an educator and a student talk over the inconsistencies in the student's thinking in order for the student to recognise that his/her conceptions were insufficient or incorrect and need to be changed. Cognitive tension occurs when the student spots discrepancies between present beliefs (his/er methods) and observed procedures (answer on examination paper). Teaching approaches which encourage the examination of misconception through debates result in deep longer term learning (Sheinuk, 2010; Swan, 2000).

Problem-based learning (PBL), in contrast with traditional learning, seems to also decrease students' mistakes and misconceptions in the Mathematics (Kazemi & Ghoraishi, 2012). PBL requires students to become accountable for their own learning. The PBL educator is a helper of student learning, and his/her involvements reduce as students increasingly take charge for their learning processes. The educator guides students during their study, pushing them to reason, and copies the types of questions that students should to be asking themselves.

Mathematics interventions should expose flawed thinking and allow students to confront their misconceptions and, consequently, discover for themselves the source of their misconceptions. Teaching and learning strategies should prepare students with approaches and methods to help them to overcome misconceptions and develop their reasoning, setting up convincing laboratory experiments, using more physical representations or introducing new technology-based methods. Formative assessment allows educators to identify misconceptions. Formative assessment is usually mentioned to as assessment "for" learning, in contrast to assessment "of" learning, which implies summative assessment. When formative assessment is used persistently, there is a change of instruction and learning (Schnepper & McCoy, 2013).

Schnepper and McCoy (2013) emphasise that the students should put sums in parenthesis, and that it is wrong to cancel out terms in parentheses except they cancel out everything. Students practise adding and subtracting rational expressions using a jeopardy game, a flow chart. Educators should use flexible teaching and learning methods so that students can use a variety of the methods to explain their thinking (Powell, 2012).

Computer software can be convenient and appropriate to support educators where time is limited. Computer software can sometimes be more useful and valuable than textbooks due to its high level of interactivity (Grossman, 1996). Computer software helps the teacher to understand why a student has certain misconceptions (Russell et al., 2009). Steinle et al. (2009) argue that the possibility of using technology to support and correct students' misconceptions with limited procedural skills is not likely to work if they have insufficient conceptual understanding. The advantages of amending misconceptions are: (i) one covers less content originally to allow students to know the material better; (ii) students' level of conceptual understanding ends up much larger; and (iii) students' curiosity and attention levels are maintained for much longer, and (iv) students can develop a specific topic over a longer period, and (v) students are less disruptive in classrooms (Henderson, 2010).

2.2.3 Types of misconceptions

The identification and classification of students' misconceptions help to know what they have not studied, and what they have neglected to learn. It will help educators to concentrate on effective approaches for remedying Algebraic problems and misconceptions. Here is a list of different misconceptions in Algebra and also some examples (Table 2.1).

Table 2.1: Different misconceptions in Algebra and examples

Misconception	Reason	Reference
Percentages and decimals	• Not well understood. • Changing decimal to per cent (and the opposite) is also misinterpreted	(Allen, 2007; Bush, 2011; Chick & Baker, 2005; Dekyi, Minshall, & Tokwe, 2007b; Olivier, 1989)
Number sense	• Students do not distinguish between rational and irrational numbers. • Some students think that $\frac{6\pi}{10\pi}$ is irrational, and repeating decimals as $12{,}\overline{689}689$, are irrational	(Allen, 2007; Craighead, 2012b; Lovell, 2010; Swedosh, 1998)
Fractions	• Literature emanates the notion that misconceptions relating to fractions lie at the root of other misconceptions in Mathematics • Example 1: Incorrect cancelling of $\frac{ad+f}{d}$ to obtain $a+f$ • Example 2: Working with large numerators and denominators rather than reducing. $\frac{26}{14}\times\frac{28}{130}=\frac{26\times 28}{14\times 30}=\frac{728}{1820}=\frac{2}{5}$ Instead of cancelling common factors as $\frac{26}{14}\times\frac{28}{130}=\frac{1}{1}\times\frac{2}{5}$ • Example 3: $\frac{1}{y}+\frac{1}{b}=\frac{2}{yb}\ or\ \frac{1}{yb}$	(Allen, 2007; Bush, 2011; Dekyi et al., 2007b; Schnepper & McCoy, 2013)
Order of operations	• Order of operations using BODMAS • Brackets first, of division, multiply, adding and last subtraction • Example: $3+3x^2=6x^2$ • Students often misuse the distributive rule $x^2-3(x-4)$ written as $x^2-3x-12$	(Allen, 2007; Bush, 2011)

Misconception	Reason	Reference
Powers	• Students have trouble with preference of operations • Example1: $-2^4 = 16$ not as $-2^4 = -16$ • Example 2: $b \times b \times b \times b$ as $4b$ and correct answer is b^4 • Example 3: $3(xyz) = 3x3y3x$	(Allen, 2007)
Square roots	• Many students have problems with the precise and correct definition • Example 1: $\sqrt{a \pm b} = \sqrt{a} \pm \sqrt{b}$ • Example 2: $\sqrt{75} = \sqrt{15}$ • Example 3: $\sqrt{5x} = 5x^{\frac{1}{2}}$	(Allen, 2007; Dekyi et al., 2007b)
Simplification/ factorisation of Algebraic expressions	• Students naturally abandon the rules and steps or misunderstand the steps in several types of simplification questions • Example: Expanding perfect squares binomials. $(b+2)^2 = b^2 + 4$	(Allen, 2007; Swedosh, 1998)
Inequalities	• Students have problems solving various types of inequalities • The offenders are inequalities involving quadratic terms and inequalities with an absolute value • The sign is a big problem, the students do not know how to interpret or read the sign	(Allen, 2007; Swedosh, 1998)
Expansion of Algebraic expressions	• The one thing the students seem to be able to do correctly is FOIL and add/subtract a constant from both sides of an equation and forgetting to change the sign • Unacceptable distribution	(Allen, 2007; Egodawatte, 2011)
Exponentials	• Students are uncertain about negative and fractional exponents • Students have problems with simplifying • They forget to use the exponential laws • Example 1: $\frac{2^2}{3^{-2}} = 2^2.3^{-2} / 2^{-2}.3^2$ • Example 2: $a^{x+y} = a^x + a^y$	(Allen, 2007; Craighead, 2012b; Swedosh, 1998)
Logarithms	• When solving a logarithmic equation, students overlook to check if the answer is in the domain; or, if they get two answers and the first one has been checked; they tend to automatically exclude the second answer • Example 1: $\log 2 - \log 3 = \frac{\log 2}{\log 3}$ instead of $\log\left(\frac{2}{3}\right)$ • Example 2: $\ln(3x) = 3\ln x$	(Allen, 2007; Liang & Wood, 2005; Olivier, 2005; Swedosh, 1998)
Functions	• Locating the area of a rational function when a common factor is existent in the numerator and denominator	(Allen, 2007; Bush, 2011; Foster, 2007; Mamba, 2005; Russell et al., 2009)

Misconception	Reason	Reference
Functions: asymptotes	• Vertical and horizontal asymptotes are often confused because students do not recognise the descriptions of which one is vertical and which one is horizontal • When asked to count how many asymptotes a function has, the student will count only the vertical ones and not the horizontal lines • The student does not know the difference between the vertical and horizontal asymptotes and does not know what an asymptote is or what the function of it is • Example: What is the domain of $\frac{x-3}{x^2-4x+3}$ • Clearly, the domain is $\{x / x \neq 3 and x \neq 1\}$ Students tend to cancel the common factor and work with what remains.	(Allen, 2007)
Variables	• Entirely overlooking the existence of letters • Not distinguishing between letters used as units of measure and as variables • Handling letters as objects such as an a for apple • Having faith in the fact that there are rules used to control which number a letter stands for • Thinking that letters always have one particular value, an m always represents metre. This is called the mixed fruit method. Often used by grade R and grade 1 teachers • Example 1: In the equation $x+2=9$, x represents the value 7. Any other value would make the equation untrue. • Example 2: 6 m and 6m are the same	(Booth & Pare-Blagoev, 2011; Egodawatte, 2011; Foster, 2007; Godfrey & Thomas, 2004; Jordaan, 2005; Mamba, 2005; McIntyre, 2007a)
Generalisations	• Overgeneralisation of numbers and their properties may be the most important fundamental root or origin of students' misconceptions • Students, who fail to recognise the critical nature of the 0, treat it just as they do the other numbers and oversimplify • Inability to simplify because of a lack of understanding of • Mathematics procedures.	(Bush, 2011; Dekyi et al., 2007b; Liang & Wood, 2005; Olivier, 1989)
Equations	• How students decide on what is or is not an equation, and their ability to use transitivity of the equals sign, and to deal with a letter as variable • The misconception may be a result of believing that you can do anything to an equation as long as you do the same thing on both sides of the equation, like adding or subtracting on both sides • The students experience difficulties with units, with accuracy and with precedence • Students add all unlike terms together and then simplify • Example1: $3y+2=10$ $-10=-10$ $\therefore 3y=2$ $y=\frac{2}{3}$	(Booth & Pare-Blagoev, 2011; Bush, 2011; Dekyi et al., 2007b; Egodawatte, 2011; Foster, 2007; Godfrey & Thomas, 2004; Jordaan, 2005; Jordan, 2007; Lovell, 2010; Mamba, 2005)

Misconception	Reason	Reference
	• Example 2 $3(x-5)^2$ $=(3x-10)^2$	
Negative numbers	• Students do not know that a negative multiplied by a negative is a positive and that a negative multiplied by a positive is a negative • Incorrect understanding of negative numbers • Students may have problems understanding the negative sign (–) alongside as "minus" and "negative." • Students may also have problems with actions on negative numbers, having learned non–mathematical rules such as "two negatives cancel each other out." • Remembering the rules for procedures, without adequate interpretation, only weakens students' abilities to make • sense of more advanced concepts, such as procedures on polynomials	(Allen, 2007; Booth & Pare-Blagoev, 2011; Bush, 2011; Jordan, 2007)
Straight lines (Gradient)	• Students overlook the fact that not all straight-line graphs go through the origin, and get confused with the axes of a graph • They find the reciprocal of the correct value—and have particular problems with negative gradients • Fail to read the labels on the axes and count squares	(Dekyi et al., 2007b; Jordan, 2007)
Place value	• Students misuse the technique for counting, and treat tens and hundreds as single and individual numbers	(Dekyi et al., 2007b)
Factorise	• Students do not know what factorise means • Students do not know there are different kinds of factorising or students do not recognise the type of factorisation	(Swedosh, 1994)

2.3 Algebra

This study focuses on misconceptions in the following three strains of Algebra: exponents, equations, and factorisation.

2.3.1 Factorisation in Algebra

Factorisation can be seen as the method of finding the terms that multiply with one another to form another term or expression (Vordermann, 2010). Factorisation is used, not only to solve for unknown variables in quadratic expressions, but also for simplification and determining the x-intercepts in functions, manipulate Algebraic expressions by adding similar terms, by multiplying a single term over a bracket, and by taking out common factors, multiplying two linear expressions, factorising quadratic expressions including the difference of two squares and simplifying expressions. The common misconception with factoring is the fact that factoring itself is a method of simplification. It is a technique of taking high degree polynomials and changing them into minor degree polynomials. Most students in high schools have troubled understanding of why they got the question incorrect. Students often do not simplify the answer they give. Most students think simplifying is having a numerical answer or an equation with all like terms added. They forget that having a factorable equation means the simplest form is the factored condition. This misconception is not a big problem, but it just makes the solution less accurate and more difficult to understand. Below are examples of factorisation misconceptions in Algebra (Table 2.2).

Table 2.2: Factorisation Misconceptions in Algebra

Example	Reference
• Cancelling before factorising, incorrect cross-multiplying $\frac{2y^2+4y}{y^2+3y+2}=\frac{\cancel{2}y^2+4y}{\cancel{y^2}+3y+\cancel{2}}=\frac{4y}{3y}$	(Allen, 2007; Bush, 2011; Egodawatte, 2011; Schnepper & McCoy, 2013; Swedosh & Clark, 1998)
• Cancelling out after factorising $\frac{y+2}{(y+2)(y+3)}=\frac{\cancel{y}+\cancel{2}}{(y+\cancel{2})(\cancel{y}+3)}=\frac{0}{3} or 3$	(Allen, 2007; Swedosh & Clark, 1998)
• Not factoring out biggest common factor, but any common factor $3a^3b-6a^2b^2-9ab$ $3a(a^2b-2ab^2-3b)$ •	(Swedosh, 1994)
• Cancelling out a common factor and forgetting to leave the one $3a^3b-6a^2b^2-3ab$ $3ab(a^2b-2ab^2)$ or $2y^2-y=0$ $y(2y)=0$	(Dawkins, 2006; Swedosh, 1994)
• Grouping incorrectly or not factorising out the common grouping. Students do not recognise the terms that have something in common $a^2b^3-2b^3-2a^2+4$ $(a^2b^3+4)+(-2b^3-2a^2)$ or $(a^2b^3-2b^3)+(-2a^2+4)$ $=b^3(a^2-2)+2(-a^2+2)$ or	(Swedosh, 1994)

Example	Reference
$a^2b^3 - 2b^3 - 2a^2 + 4$ $= \left(a^2b^3 + 4\right) - \left(2b^3 - 2a^2\right)$	
• Not factorising completely, the students do not check the brackets again $y^8 - 1$ $\left(y^4 - 1\right)\left(y^4 + 1\right)$	(Swedosh, 1994)
• When factorising trinomials the students forget that the sum is not the middle term and forget to test the factorisation signs $y^2 - 5y + 6$ $\left(y - 6\right)\left(y + 1\right)$	(Rushton, 2014)
• If c=0 (constant number), using coefficient of b as last term $y^2 - 8y$ $\left(y - 2\right)\left(y + 4\right)$	(Swedosh, 1994)
• Students do not recognise difference of squares $\left(x + 2y\right)^2 - y^2$ $\left(\left(x + 2y\right) - y\right)\left(\left(x + 2y\right) + y\right)$ $\left(x + 2y - y\right)\left(x + 2y + y\right)$ $\left(x + y\right)\left(x + 3y\right)$ or $4y + 14$ $4\left(y + 3.5\right)$ or $y^2 - 25$ $\left(y - 5\right)^2$	(Bush, 2011; Rushton, 2014; Swedosh & Clark, 1998)
• Zero product principle error, where equation must be equal to zero to solve $y^2 - 10y + 21 = 12$ $\left(y - 7\right)\left(y - 3\right) = 12$ $\left(y - 7\right) = 12$ $\left(y - 3\right) = 12$	(Dawkins, 2006; Olivier, 1989)

2.3.2 Equation in Algebra

An equation is a statement that two numbers or variables are alike and have two sides (Dekyi et al., 2007b). Any given equation contains a number of features that may be more or less fundamental to its understanding. These characteristics consist of, but are not limited to, the equals sign (=), operation signs (+, -, ×, ÷), variables (y, a), and a variety of types of numbers (21, ¼, .124,) which may appear as constants, coefficients (e.g., .21y), exponents (e.g., 2^x) or other roles in the equation (Booth & Koedinger, 2008a; Foster, 2007). Obtaining an accurate understanding of variables in an equation is a challenge many students encounter when learning Algebra (Lucariello, Michele, & Colleen, 2014a). One of the most frequent misconceptions students have in developing an understanding of equations is the relevance of the equal sign (=). Students ignore the equal sign as "an operation equals answer." Procedural misconceptions happen because students do not keep equations in equilibrium by execution operations on one side of the equation only (Powell, 2012). Examples of equation misconceptions are available in Table 2.3.

Table 2.3: Equations Misconceptions in Algebra

Example	Reference
• Disregarding exponents when calculating expressions $2\times8^3 = 3$	(America's Choice, 2006)
• Multiplying by an exponent rather than multiplying the expression by itself. Insufficient understanding of index laws reading "5 squared" as "5 doubled" • Students do not use standard algebraic rules and principles. Students write expressions as in arithmetic $y*6=2$ rather than $6y=2$	(Swedosh & Clark, 1998)
• Students do not use parentheses when they are required to understand the expression $y+6*2$ rather than $2(y+6)$	(America's Choice, 2006; Rushton, 2014; Welder, 2012)
• Students do not use regular algebraic rules and laws for exponents. Students write expressions as in arithmetic $y*y*y$ rather than y^3	(America's Choice, 2006; Cangelosi et al., 2011)
• When simplifying expressions, students write similar terms next to each other but do not add together $5+3b+5+b+2b=10+3b+b+2b$	(Lucariello et al., 2014a)
• Students do not distribute multiplication or negative to very term in the parentheses (misapplication of the distributive rule and laws) $3(a+2)=3a+2$	(Allen, 2007; America's Choice, 2006; Dawkins, 2006; Rushton, 2014)

Example	Reference
or $3(3x-4)^2$ $(9x-12)^2$ or $3-(x-y)$ $3-x-y$	
• Students distribute multiplication by a negative term (or subtraction) to only the first term in an expression $a-3(a+2)=a-3a+6=-2a+6$	(Booth & Koedinger, 2008b; Rushton, 2014; Schnepper & McCoy, 2013)
• Students read the equality sign as "makes" without bearing in mind what is on the other side of the equation $5+6=x+3$ as $5+6=11$	(Steinle et al., 2009; Welder, 2012)
• Students confuse negative signs when adding and subtracting terms $2y+10=y$ as $y=10$ rather than $y=-10$	(Powell, 2012; Welder, 2012)
• Students reason that a variable can only stand for one specific number or answer	(Egodawatte, 2011; Welder, 2012)
• Students think that different variables must stand for different answer $y+3\neq x+3$ because x and y cannot be the same answer	(America's Choice, 2006; Egodawatte, 2011; Sahin & Soylu, 2011; Steinle et al., 2009; Welder, 2012)
• Procedural mistakes occur because students do not keep equations in balance	(Welder, 2012)
• Students understand the equal sign as "do something."	(Booth & Pare-Blagoev, 2011; Foster, 2007; Powell, 2012)
• Students add together unlike terms and students believe (+) and (-) cannot be left in algebraic answers $2y^2+6y=8y^2$	(Kaur, 1991; Luneta & Makonye, 2010; Welder, 2012)
• Flipping equations over $\frac{4}{x}=\frac{2}{a}+\frac{5}{b}$ $x=\frac{2b+5a}{ab}$ $x=\frac{4ab}{2b+5a}$	(Bush, 2011; Swedosh, 1994; Swedosh & Clark, 1998)
• Answer cannot be in an expression form, it must be singular form	(McIntyre, 2007b)

2.3.3 Exponents in Algebra

An exponent is a symbol indicating how many times the number or variable is to be multiplied by itself to produce the power or index presented (Vordermann, 2010). Exponents can be used in simplification but also in solving equations. Although most students see exponents as a new number set, this concept is in fact represented the abbreviated form of repeated multiplication. Students who lack a basic or primary understanding of exponents often have countless problems in classifying between negative bases and negative exponents. Examples of misconceptions of exponents are available in Table 2.4.

Table 2.4: Exponent Misconceptions in Algebra

Example	Reference
• Thinking that a number raised to the power is the same as the number multiplied by the power $3^4 = 3 \times 4 = 12$	(Allen, 2007)
• When adding numbers, expressing the addition using a power $3+3+3+3 = 3^4$	(Allen, 2007; Olivier, 1989)
• Not understanding how to simplify an expression using exponent and parentheses thinking that $\frac{1}{4^2}$ is not equal to $\left(\frac{1}{4}\right)^2$	(Swedosh, 1994)
• Thinking that a root of a number is the same as the number divided by the root, $\sqrt[2]{5} = \frac{5}{2}$ or $\sqrt{5x}$ $(5x)^{\frac{1}{2}}$ $5x^{\frac{1}{2}}$	(Allen, 2007; Dawkins, 2006)
• Make sure those students that squaring a number are not the same as doubling the number, except for the unique case of 2^2 Note the difference $4^2 = 16$ and $4 \times 2 = 8$	(Cangelosi et al., 2011)

Example	Reference
• Thinking that a number to a negative power is multiplied by the power $5^{-2} = 25$, $10^{-3} = -1000 or -\frac{1}{1000}$	(Allan, 2007; Cangelosi et al., 2011)
• Ignoring a negative power if it is in the denominator $\frac{1}{3^{-2}} = \frac{1}{9}$	(Allan, 2007; Dawkins, 2006; Ozkan & A, 2012)
• Thinking that a number raised to a negative power is multiplied by the power $x^{-2} = -2x$	(Allen, 2007)
• Thinking that an expression to the zero power is equal to that expression $x^0 = x$	(Ozkan & A, 2012)
• Not recognising the meaning of parentheses in a expressions $(2y)^3 = 2y^3$	(Dawkins, 2006)
• Not recognising their must be two answers $y^2 = 25$ $y = \sqrt{25}$ $y = 5$	(Dawkins, 2006)

2.4 Curriculum of N2 Mathematics of the College sector

The curriculum of N2 Mathematics describes what is needed to complete the course in a period of twelve weeks. This curriculum includes:

- Exponents: Reproduce the laws for exponents and their derivatives, apply the laws for exponents and the derivatives in simplifying Algebraic expressions and solve exponential equations.
- Factorisation: Factorise a polynomial by taking a common factor as a first step followed by taking out a binomial as common factor as a second step; factorise a quadratic trinomial of which the coefficient of is any whole number; factorise the difference to two squares, and do multiplication, division, adding and subtracting of fractions.

- Equations: Solve linear equations without fractions and solve quadratic equations according to a specific method, i.e. factorisation or the quadratic formula (Van Rensburg, 2003) .

2.5 Technology in Mathematics

Educators at different levels have been confronted over the past years by a wide range of technologies aimed to support and contribute in education. A number of technologies including television, laptops, demonstration software, audio-visual gaming, and simulation programs have been indicated as having the possible of changing teaching, yet most of what goes on in education remains to depends on educator-student collaboration (Picciano, 2009). Research shows that educators are moving away from the chalkboard and moving into the domain of calculators, computers, and other technologies (Bismarck, 2009). The use of technology has a wide history in Mathematics education. The use of technology may assist creating procedures that encourage problem-solving skills, higher-order skills, self-regulating learning, and lifelong learning (Honey, 2005). Students can study Mathematics more deeply with the suitable use of technology. In Mathematics instruction programmes, technology should be used extensively and correctly, with the objective of improving and developing students' learning of Mathematics (Barnes, Ferrini-Mundy, & Martin, 2000).

Technology could be a valuable instrument for the Mathematics educator, but many educators are trapped between their tested and reliable pedagogical techniques and a world that is moving more rapidly. Presenting technologies into classrooms have traditionally been met with mixed levels of conflict and interest. Nevertheless from pencil (talk-and-chalk) through to calculators and computers, the frequently increasing range of educational technologies tools moving onward has impacted classrooms and education. The teaching spaces where technology was used had a twelve per cent increase in results, other than the classes where no technology was used (Birch & Sankey, 2008; Bolliger, Supanakorn, & Boggs, 2010; Kiong & Yong, 2001).

Adamides and Nicolaou (2004) came to the conclusion that students have a more positive attitude and approach towards the use of technology than towards Mathematics. The combination of technology with Mathematics stands a chance to increase the interest towards Mathematics. Educators who use technology in their Mathematics courses pointed out that they do it not only because they feel they have to keep up with technology, but also because they want to develop, enhance and improve their teaching skills. Mathematics taught within well-designed technology provides students with chances to study Mathematics in contexts that they know and understand, and can lead to cross-discipline association of content and procedures (Adamides & Nicolaou, 2004; Eli, Higashi, Scoop, & Schunn, 2010).

The advantages that students gain from the use of technology in education are (a) visually active support for graphics and diagrams, (b) opportunities for students to share their reasoning, (c) increased student risk-taking and (d) improved problem solving skills (Bolliger et al., 2010). There are many positive effects of technology mixing and incorporation into Mathematics, such as: improving approaches toward studying, improving student success and bettering theoretical and abstract understanding (Mustafa al-Absi & Abed, 2014). It has been found that when technology makes theoretical ideas real, educators can more without doubt:

- build upon previous knowledge and expertise
- emphasise the networks among Mathematics ideas
- join concepts to real-world circumstances
- attend to address common misinterpretations, misconceptions
- present more advanced concepts, and ideas.

Technologies are becoming imperative as these have initiated new routes for the teaching and learning development—furthering both the educators and students. Educators can use technology to present better Mathematics. For example, educators can emphasis less on learn by heart facts and performing procedure and more on developing thoughts, studying and investigating consequences, explaining solutions, and understanding associates—the actual heart of Mathematics. Both the opportunity to teach Mathematics better and to teach better Mathematics should be considered in school technology strategies and educator professional progress and development.

The computer access and availability in South African schools is thirty-eight per cent, and only about fifteen per cent of Mathematics and Science educators use technology in their education (Nygren, Sutinen, Blignaut, Laine, & Els, 2012). Most educators merge content and pedagogy but leave out technology. In the greater part of schools in South Africa technology has had no influence and effect on education results (Ndlovu & Lawrence, 2012; Van Wyk, 2014). The educators are using technology to simply pass on subject knowledge rather than use the technologies to improve teaching and learning. Here are a few examples of technologies available in South Africa for the use of the educator:

- Global Teenager Project: Brings together students around the planet through web-based classrooms.
- School Communicator: The School Communicator is an integrated communications solution that agrees schools to connect with parents using a diversity of online and mobile instruments.
- Mindset Learn: Mindset Learn provides curriculum-associated e-learning subject matters and content over television and Internet for use by students and educators in any place.
- GSES Integrated Mathematics Programme: A Mathematics development programme that incorporates online student assessments, educator development, student performance analysis and targeted student support,

The educator needs to blend the elements of teaching in a balanced way, technology, pedagogy and content. The adoption of blended learning can enhance teaching and learning.

2.5.1 Blended learning

Blended learning, accessible learning, hybrid learning and e-learning are all languages or terms which have been used to define the use of synchronous and asynchronous approaches of assisting learning through technological resources (Akyüz & Samsa, 2009). A method of technology enhanced learning which has also been described as blended learning (Jefferies, 2010). Blended learning method blends traditional teaching approaches with computer-based activities, causing in a combined learning encounter for students (Rothrauff, 2011). Blended learning suggests that components of different approaches, notions, and didactical principles, typically used in isolation, are now added together to match and benefit the requirements of the student for a complete learning experience. Therefore blended learning is a new instructive and scholastic model with the possibility to increase student results and create new roles for educators (Geçer & Dağ, 2012).

The objective of a blended method is to leverage the finest characteristics of both traditional and online learning to the students' advantage (Rothrauff, 2011) and it offers an extra teaching space—the computer-generated one. The reasons given by Allan (2007) for creating blended learning are: (a) making learning more easy to reach, (b) offering more adaptable learning opportunities, (c) cut down on the quantity of time spent on traditional learning, (d) mixing practitioner-based skills with classroom-based education, and (e) improving databases that are cheap to duplicate or can be applied to large groups of students. Blended learning can be used in academic and business circles (Wai & Seng, 2014).

The advantage of using a blended method is using lecturing time for explaining concepts and steps. Computer base activities can be finished at any time of day, wherever the student has access to a computer (Rothrauff, 2011). Another advantage of blended learning is that it lets students experience education in ways in which they are relaxed, while motivating them to experience and study in additional ways (Picciano, 2009). The usage of blended learning tools provides a quality and welcoming learning situation as a whole for the students using blended learning (Wai & Seng, 2014).

2.5.1.1 Research on blended learning

Kashefi *et al* (2012) show that blended learning helps and assist students' mathematical reasoning and helps in overcoming extra problems and difficulties in Mathematicsl learning. Study of the outcomes discovered that using different communicating elements helps students to identify with the idea of two-variable functions. This technique could help students to select a suitable world of Mathematics and to change from one Mathematics domain to other. Using communicating tools and cartoons leads most students to better understand the area and field as well as how to sketch it. Using different types of theoretical, graphic, and figurative insights and appropriate reminders and questions causes students to recollect prior mathematical construction properly and correctly (Kashefi et al., 2012).

According to Piontek and Hudson of DreamBox (2013), students want a bigger say and flexibility in what, when, where, and by what method they are teach. The students that took part in the study of Vaughan and Garrison (2005) indicated that the traditional teaching method was their chosen medium for the introduction of new topics. However, they also stated that the online sessions were valuable and beneficial for supporting the topic.

2.5.1.2 Disadvantages of blended learning

Blended learning cannot not help the student with poor prior knowledge (Kashefi et al., 2012). Blended learning works only for the small portion of students who are self-directed (Piontek & Hudson, 2013). Computer programs that are not updated can be a problem, or programs that keep on changing can create problems (Brew, 2008; Wai & Seng, 2014). Blended learning is a modernisation and improvement in education that can take many forms. There are times when a student already has contextual knowledge and data about a topic or a theory. Then there are times where they need a little help or assistance. Using screencasts is just one of the ways to let students to move through the subject area at their personal speed.

2.6 Screencasts

Screencasts are brief digital recordings comprising a computer screen capture with audio which can be used online or sent to students with insufficient internet networks on a CD or DVD. A screencast can also be a narrated video with a tutorial objective which might take the form of a formal narrated PowerPoint presentation, a software demonstration, or an easy-going explanation of concepts (Adamides & Nicolaou, 2004; Hurford & Read, 2011; Udell, 2005; Wilkes, 2012b). Screencasts can be seen as a single source of quality information, giving multiple revision opportunities; gaining of new knowledge in a short format and in an informal learning environment of multimedia-rich learning material designed to address diverse learning styles (Feinstein, 2010; Palaigeorgoui & Despotakis, 2010; Pinder-Grover, Millunchick, & Bierwert, 2008; Wakefield et al., 2011).

Screencasting saves valuable time for educators by not expecting them to repeat examples, models, and patterns numerous times (Mullamphy, Higgins, Belward, & Ward, 2010). Screencasts get the students involved, helping them to focus on more advanced concepts and procedures, bettering the reviewing method, and improving learning process. The student can use the screencast again and again. The corresponding audio and video on screen helps to hold students' interest and allows the 21st century student to study in a more self-directed approach (Feinstein, 2010; Palaigeorgoui & Despotakis, 2010; Peterson, 2007; Sugar, Brown, & Luterbach, 2010; Thompson & Meredith, 2012). The flexibility offered by the screencast was commented on by students and it was a very useful tool for combining with lectures and also for doing revision (Warfvinge, 2012).

Screencasts may be instrumental in addressing the different learning styles of diverse students (Kanter, 2007), but also allow the students to learn in a more self-directed approach, one that suits the individual student's style and speed of learning, and provide an effective way of learning; students can be shown how to accomplish a specified assignment and exercise or be taught on a given topic (McGovern, 2010). Some screencasts are carefully created works, intended to teach (Udell, 2005).

A screencast can be used in different ways: Tutorial, short how-to, conversational demo, feature story, software review, and user-produced demo (Udell, 2005). The uses for screencasting are boundless; these consist of providing course orientations, instructional lectures, providing response, and reassuring student partnership. The use of screencasts does not threaten the existence of the traditional lecture, but expands its possibilities and audio visual explanations. Screencasts can better meet students' needs and be clearer than written instructions (Mohorovicic, 2012). According to Pinder-Grover et al. (2008), students acknowledged the following uses for screencasting: to explain misinterpretations, to increase the lecture material, and to asses for examinations or tests. The positive student views and influence on student results show that short screencasts could play a valuable role in studying requirement Mathematics (Loch, Jordan, Lowe, & Mestel, 2014).

Screencasts happen in real time and can be used in old-fashioned education space, intervention settings, distance education situations, and as extra data to textbooks and workbooks (Mooney & Spitzer). Mooney and Spitzer () also state that screencasts have made the classes more accessible to their students, and screencasts have changed the way they control classes, the way the students learn, and the way they teach. Peterson (2007) indicates that screencasts could be used to supplement teaching materials across all disciplines. Screencasts can be attached to emails for distant students. The capability to inquire about problems and receive instantaneous reactions from an expert educator is significant to students, as is learning through collective communication, being in a lecture with other students and educator.

More recently screencasts have been used in Mathematics, Physical Science and Engineering. In a study at James Cook University screencasts were used successfully to enhance Mathematics lectures. Mathematics screencasts enable the actual recording of handwritten step-by-step explanations of problems including specialist Mathematics notation (McLoughlin & Loch, 2012). The screencasts involve a deep understanding of the Mathematics procedures and proper execution of the abilities and thinking skills (Murray, 2008). Screencast are well suited to demonstrate basic Mathematics concepts by allowing communication through multiple writing, visual aids and speech (Jordan, Loch, Lowe, Mestel, & Wilkins, 2012b).

Mathematics screencasts produced by online students as assessments help the students to obtain, comprehend and retain knowledge more efficiently than most old-fashioned learning approaches and procedures (Murray, 2008). Content as well as procedural knowledge is tested and improved (Wilkes, 2010; Williams, 2010). Screencasts have been found to be important by all students, even those who are excellent at Mathematics (Akilli, 2008).

Palaigeorgoui and Despotakis (2010) present studies that the value of screencasts in education, long-term remembering and transferability of knowledge was found to depreciate in post-tests of students' performance, showing an absence of deeper learning of content and procedures. Mohorovicic (2012) indicates that it is time consuming to create screencasts, and that the audio quality may not be as significant as the content. Difficulties using screencasts can be isolated into technological and learning matters (Wilkes, 2010). Research has shown the positive impact of screencast as a supplementary resource to aid student learning (Pinder-Grover, Green, & Millunchick, 2011)

The students in the article "Do short screencasts improve student learning of Mathematics?" (Jordan et al., 2012b) express the opinion that the screencasts were an improvement on just picking up a technique from the notes, and showed how to use technique and procedures. After Winterbottom (2007) used screencasts, he obtained feedback from students with questionnaires. The feedback was very constructive, with flexibility and the ability to repeat lessons, but caution must be used in that screencasts should not replace face-to-face or traditional teaching.

Palaigeorgoui and Despotakis (2010) express the opinion that screencasts have emerged as a smart learning medium due to their validity, their software affordances, and the feeling of personal and individual contact that they engender. The students regard screencasting as tools that initiate learning by providing a specific range of learning paths, with clear goals and possibilities, by means of a trustworthy and interesting demonstration. The students confirm the interesting and true nature of screencast and characterise them as *fascinating, entertaining, live, helpful, and comfortable*. The students state that they could easily copy procedures with screencasts, and they learn with screencast in a more resourceful way compared to textbooks, e-books and web pages.

Feinstein (2010) used a tablet PC and screencasts when teaching Mathematics to students and these were their comments: (a) they find it helpful to access the slides and recordings just after each class, if they are suspicious that there may be an error in their printed notes; (b) the students who did not attend classes due to illness or a valid reason appreciate screencasts because they are better than printed copies and, (c) the students use the screencasts to go back to the work they feel that they have missed some valuable verbal explanation on. This is especially supportive for students who are not native English speakers.

The Swinburn University of Technology gave a demonstration on and conducted a debate of the use of screencasting in a first year Operations Research course to full time and part time students at a dual-mode University Loch (2010). In addressing the question on what the consequences of using screencasting for Mathematics online learning were, they indicated that online students remained engaged and overcame feelings of isolation while learning with screencasts, which can be downloaded to portable technology as iPads and iPhones. It enables the students to study wherever they are and it is a step by step walk through solving Mathematics problems. It appears that watching a screencast takes as much time to captivate as an old-fashioned class, without the chance to inquire about problems and some steps.

Loch (2009) asked the question, “What do on campus students do with Mathematics lecture screencasts at a dual-mode Australian university?” Many of the students did not access the screencasts after the first week, but the statistics also show that 68% of students using screencasting believe they can study just as well using this screencast as they can with traditional teaching (Loch, 2009). From the discussion it appears that the online students may remain involved, having conquered the feeling of seclusion and unreachability when the lecturer is given a voice and becomes a real person, rather than an impersonal technology-facilitated entity.

Pinder-Grover *et al.* (2008) used screencasts to enhance student learning and indicated that most of the responding students found screencasts supportive, whether they found a step or problem problematic or not. Research by Jordan has focused on evaluating the significance and effectiveness of short screencasts as learning support resources for students (Jordan et al., 2012b). The evidence showed that the students like short, to the point screencasts recorded by a professional; moreover, screencasts can be a useful tool to support student learning and conceptual knowledge (Warfvinge, 2012).

Admad *et al* (2013) describe a case study undertaken to discover college students’ opinions of the advantages of screencasts in improving their Mathematics knowledge and skills at an Irish institute of technology. The data indicated ten advantages of screencasts, which included backing flexible and differentiated education, complementing lectures and improving interpretation of key procedures, supplying an indirect learning understanding, simplifying exam- and content review, offering multimodal assistance for Mathematic learning, helping students to keep track with Mathematic components and areas, filling up gaps in class work, serving as a recollection assistance, providing a close-fitting match with course content, and making Mathematic learning more pleasant and easy going. The results have positive implications for screencasts as an instrument for Mathematic education in upcoming decades. Existing research suggests that positive learning outcomes related with screencasts are more likely produced by how they are used as an education resource, rather than by the technology itself. Not only do screencasts improve learning outcomes, they have also been found to be engaging and effective in delivering subject content and procedures (Ahmad, Doheny, Faherty, & Harding, 2014).

Education is for everybody, but the method we offer and deliver education and the way students accept it is not the same for everybody. A classroom with screencasts gives educators the flexibility to meet the learning requirements of all their students, and it gives students the flexibility to have their needs met in numerous approaches and ways (Ahmad et al., 2014). By using screencast, it creates and generates a classroom that is student-centred. In terms of whether screencasts are the solution for students with different mathematical abilities, one has to remember that it is not the software that will produce results, but the educator. If the educator is successful in face-to-face class, then these methods can be used when creating screencasts to produce resources for the students to assist them. Not only do screencasts enhance learning outcomes, they are also found to be engaging and efficient in delivering content Put side by side to additional learning technologies such as PowerPoint and pod-casts as well as to traditional approaches, screencasts are considerably more appealing for students in the college sector (Mullamphy et al., 2010). Existing research proposes that constructive learning outcomes related with screencasts are more likely caused by how they are used as a resource, rather than by the technology itself (Ahmad et al., 2014).

2.7 Metacognition in Mathematics

Students are ask to do more than just show their answers—they ask students to explain their thinking, make sense of problems, construct arguments, and communicate. Understanding in the classroom leads an educator to establish and distinguish situations where the failure of a student happens. Understanding in Mathematics is making connections between ideas, facts, or procedures. The connecting is linked to existing networks with stronger or numerous connections (Shannon, 2008). There are different kinds of connections that students create. Educators have become aware that many students are able to study the required formulas and relate them to the range of textbook and test circumstances, but when faced with different and difficult problems, they show that they are far from understanding the concepts and knowing what procedures to use. Educators must provide students with an effective way to obtain, store and express data (Weimer & Jaschick, 2013). Students do not spend much time thinking about learning and the learning process. The educators must help the students raise their awareness of their own thinking processes and become better at thinking skills(Shannon, 2008). It can help students improve their understanding for teaching themselves and develop constructive learning shift to different situations and procedures (Kim, Park, Moore, & Varma, 2013).

Metacognition can be seen as higher-order thinking that assists understanding, breakdown, and handling of one's cognitive processes, especially when involved in learning (Dictionary., 2009). Metacognition refers to the expertise or ability to think about our thinking—the skill to consider what we familiar with, how to evaluate what we know, when to retrieve the suitable information (Weimer & Jaschick, 2013). Metacognition is defined as a person's capability to adapt cognitive actions and improve understanding (Van der Walt & Maree, 2007). Many educators believe that it is worthwhile to develop students' metacognitive understanding and abilities (Ader, 2009; Rysz, 2005). Two characteristics of metacognitive strategy are that it must be memorable (self-monitoring) and it must be accurately represented to the students (self-regulation or control corresponding)

(Cao & Nietfeld, 2007; Okoza & Aluede, 2013). Self-monitoring means to keep track of where one is with one's aim of interpretation, constructing and recalling (a bottom-up process). In contrast, self-regulation or control refers to dominant executive actions and comprises of planning, guiding and assessing one's performance or actions (a top-down process). When a student uses self-monitoring in learning an assignment or procedures, he or she is involved in inductive approaches. This engages learning from chunks to the whole. In self-regulation, learning is from broad-spectrum to the particulars detail (Okoza & Aluede, 2013).

Metacognition has been highlighted in connection with the ability to learn how to learn, Mathematics problem solving, and Mathematics sense making (Ozsoy & Ataman, 2009). The skill of problem solving is the core of Mathematics. There are a number of studies that report the positive influences of metacognition on problem solving and Mathematics performance (Kim et al., 2013). Mathematics metacognition is only ideas or methods that students use for problem solving. Problem solving in Mathematics is the method to find answers to a problem when the method is unknown to the student. Then the student has to use skills to select the suitable methods to get a correct answer (Ozsoy & Ataman, 2009). The educator's expert questioning plays an important role in this context, helping students to recognise thinking procedures, to see the connections between concepts and to shape new understanding as they work their way to an answer that has a meaning to them; therefore metacognition skills can be developed through instructions of the educator (EduGain, 2011).

Metacognitive strategies positively impact students who have learning problems (Onu, Eskay, Igbo, Obiyo, & Agbo, 2012a). Strategies should be taught to students with studying difficulties. However, Mathematics metacognitive strategies are shown after the student has achieved an adequate understanding of the Mathematic concept or skill. Strategies are not meant to be for conceptual understanding. There are two characteristics of metacognition: (i) reflection—thinking about *what* we identify; and (ii) self-regulation—managing *how* we go about learning. Taken together, these processes make up an important aspect of learning and development. Developing these metacognitive abilities is not simply about becoming great students, but about obtaining particular learning approaches as well (Darling-Hammond, Austin, Cheung, & Martin, 2009a) Mathematics educators should show several ways of solving a problem so that students will not have misconception that there is a certain formula or process in solving problem (Nool, 2012a). In mathematical thinking it is essential for the student to understand the hierarchy of the concepts in the different areas. Besides the algorithms and heuristics the students have to learn to use their present knowledge in new problem solving conditions and control their on-going problem solving process (Schoenfeld, 1987).

Young (2010) suggests that metacognition plays a significant role in students' achievement in Mathematics courses, but is not required to be effective in Mathematics classes. The students can handle any problem with basic steps. The student breaks the problem down into smaller parts and finds a solution using this method. At the end the student tests him/herself and learns to use the method not only in class but also in real life situations. The student learns to think about his thinking.

It is assumed that poor metacognitive skills would lead to disappointment in problem solving, and that good metacognitive skills would improve the odds in solving problems (Ozsoy & Ataman, 2009). Likewise, poor learning strategies are often connected to underachievement and shortage of motivation in learning. There are, unfortunately, no methodical, well-conducted research statistics to back the efficiency of the metacognitive approach among students (Yoong, 2002).

Judging by the results of Van der Walt and Maree (2007), the presentation of metacognition and the use of metacognitive skills and strategies in Mathematics classrooms remain a test for tertiary training institutions and schools. Apparently, very few educators either recognise or know to use these skills or strategies in Mathematics classrooms in South Africa. Educators' epistemological expectations and their classroom exercises need to be investigated and tested with an opinion to bettering the standard of Mathematics education in South Africa (Van der Walt & Maree, 2007).

The study of Du Toit and Du Toit (2013) indicates that the students were not aware of the significance of a vital characteristic of problem-solving. A second goal was to confirm the level of Mathematics success in a problem-solving setting. Only one student answered the problem successfully, joint with many conceptual mistakes, which points to inadequate achievement in a problem-solving background.

Examination of the methods of students could help educators to identify students' misconceptions of certain mathematical concepts. It may appear that a student recognises a mathematical concept and then a student's understanding falls apart. Perhaps some essential part of background knowledge is misunderstood, perhaps one too many idea is introduced. A cascading failure in understanding a mathematical concept can be set in motion by a single weakness in the understanding of that concept (Mowat, 2010).

Effective, maintainable education environments in Mathematics should encourage the development of student problem-solving skills because it shows true accomplishment in Mathematics where a high level of learner metacognition is confirmed. Hence it is recommended that education stakeholders should sincerely tackle the issue of improving student metacognition and student problem-solving skills (Du Toit & Du Toit, 2013). Educators should not try to basically pour data into students' minds as 'if they were vessels. Rather, students should be encouraged to investigate their domain, discover information, reflect, and think analytically. To accomplish this, metacognition, which performs as the tutor or instructor of a student's education, should be practised in colleges and education intuitions. By teaching students in metacognitive skills, the students can be made aware of the influence of wrong associations, insufficient models or an ineffectual handling of models, inadequate principles, and incorrect generalizations to control their influence and their answers (Egodawatte, 2011).

2.8 Summary

An identification of student misconceptions, and effective approaches to help students prevent them, is an important strain of Mathematics. In addition to trying to explain Mathematics in such a way that students avoid and escape misconceptions, educators must also have methods for dealing with those that unavoidably arise. Once the misconception is acknowledged and identified, educators must choose what approaches they can use. If re-teaching occurs then choices must be made about what to highlight and in what way. Cognitive conflict is an approach, in which students encounter a situation that contradicts their original understanding in the hope they will then re-evaluate those opinions (Kabaca, Karadag, & Aktumen, 2011). In tackling student misconceptions educators' methods must emphasis on procedural or conceptual aspects (Chick & Baker, 2005). Using technology, screencast in class can help the educator and the student. The screencast helps students, promoting their different understanding of the content, and generates an atmosphere for self-regulation and thinking about the process of getting the correct answers. Therefore screencast, set in a blended learning environment, with the correct teaching methods for example with metacognitive approaches can help a student to understand his or her misconception. The blended method meets the requirements for a diverse range of students. Students are represented by different age groups, different backgrounds, and different learning types (Picciano, 2009).

Chapter Three

Case study research design and methodology

3.1. Introduction

This chapter unpacks the methodological aspects used during the different phases of the study of N2 Mathematics students' Algebraic misconceptions. Furthermore this chapter examines if the participants' perceptions of these misconceptions and experiences about the use of screencasts could be used as teaching and learning tools to address their misconceptions. A description is provided of how these aspects link to holistically address the research question. This discussion comprises a review of the methodologies used during the different phases of the study, sampling techniques, data collection instruments, data analysis methods, ethical issues, and validity and reliability strategies.

3.2. Research design and methodology

3.2.1 Research paradigm

Researchers decide on the philosophical assumptions that underpinned the research at the beginning of a study. Burrel and Morgan (1979) describe four philosophical assumptions relating to ontology, epistemology, human nature and methodology (Figure 3.1). The ontology of research relates to the "very essence of the phenomena under investigation" (Burrel & Morgan, 1979, p. 1). The main decision is how the researcher viewed the reality to be investigated, i.e. as external or internal. Epistemology investigates the nature and origin of knowledge (Burrel & Morgan, 1979). This study aims to directly improve instructional practices and therefore relates to the constructivist (pragmatist) paradigm. The dominant approach in the functionalist paradigm is to provide rational explanations of social affairs, hence making it a highly pragmatic orientation. It is concerned with understanding society in a way that generates knowledge which is useful (Burrel and Morgan, 1979). The study therefore made use of pragmatist research methodologies of mixed methods (Wang & Hannafin, 2005b) in order to provide guidelines for best practices (Engelhart, 1997) relating to N2-level Mathematics students' misconceptions about Algebra.

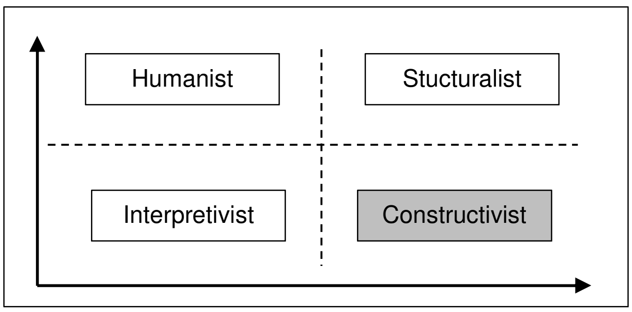

Figure 3.1: Four paradigms for the analysis of social theory (Burrel & Morgan, 1979, p. 22)

3.2.2 Case study research

A case study is a thorough evaluation of a particular entity where a controlled number of components of analysis is reviewed intensively (McMillan & Schumacher, 2014; Wellman et al., 2005). A case study is a pragmatic investigation that examines a contemporary singularity comprehensive and within its real-life background, particularly when the limits between singularity and situation are not clearly obvious. The case study inquiry copes with the theoretically distinguishing situation in which there will be numerous variables of importance. An outcome depends on numerous resources of confirmation, where data are required to assemble in a triangulating approach. Another consequence is the benefit from preceding expansion of hypothetical suggestions to influence data gathering and examination (Yin, 2009).

According to Maree (2007), case study research is a method in which the researcher investigates a bounded arrangement (case) or multiple bounded arrangements (cases) over time, through comprehensive, detailed data collection including multiple sources of data, and reports a case description and case-based themes. Case studies provide opportunities to study particular subjects, e.g. an organisation, or a group of people. Case studies involve the gathering and analysing of information that may be qualitative and/or quantitative in nature.

The primary purpose for undertaking a case study is to explore the particularity, the uniqueness, of the single case. Consequently, case studies are appropriate when research focuses on either a *descriptive* question (What is occurring or has occurred?), or an *explanatory* question (How or why did something occur?). By highlighting the occurrence of a phenomenon within its real-life framework, the case study method promotes the gathering of data in natural circumstances and it associates with the resulting data (Yin, 2009). There are three different types of case studies, (i) intrinsic case studies where the research is mainly interested in understanding a particular person or circumstances, (ii) instrumental case studies where the researcher is in interested in studying the specific case in order to form concepts (Mills, Durepos, & Wiebe, 2010), and (iii) multiple case studies where the researcher investigates numerous cases in order to draw generalities (Fraenkel, Wallen, & Hyun, 2012).

Using case study methodology holds various advantages and disadvantages. Some of the advantages relate to:

- **Concentrated study**. Case study method is accountable for a concentrated study of a specific unit. It is the methodological and intense examination of an occurrence. Case studies allow much data to be accumulated that would not have typically been obtained through other research designs. The data obtained are in general affluent and of great depth.
- **No random sample.** It studies a communal unit in its complete viewpoints and therefore statistical sampling is not part of strategy. Case studies are likely to be conducted on occasional circumstances where substantial samples of related participants are not available.
- **Uninterrupted analysis.** Uninterrupted analysis is valuable in analysing a collective unit.
- **Associations.** It associates dissimilar facts during the study of a unit.

- **Improvement in knowledge.** Provides investigative control to an individual to increase knowledge on a communal occurrence.
- **Generalisation of data**. Case study method delivers foundations for generalization of data for exemplifying statistical conclusions.
- **Comprehensive.** Relates to an all-inclusive method of data collection during communal research.
- **Uncover different cases.** Different cases may behave in contradiction of the intended hypothesis and the aim of the research is to pinpoints these different cases.
- **Drawing of a hypothesis.** It is useful to formulate hypotheses for further study. Case studies can assist in adjusting ideas and produce innovative hypotheses which could later be tested. (Farooq, 2013; Yin, 2009).

Some of the disadvantages relate to:

- The accumulated data cannot automatically be generalised to the broader population.
- Case studies normally relate to a single researcher who gathers data. This could lead to biases which influence the results of the study.
- It is difficult to draw cause or effect from case studies.

This study is particularly appropriate for a case study design as it is a bounded system. Bounded cases are unique studies in terms of time period, place, physical boundaries, social groups, organisations or geographical area (Creswell, 2009). It is possible to create limits around the target under study. A case could comprise a single person, a group, a school, a society, a programme, outcomes, or activities. The bounded case relating to this study relates to the NCRFET College in Kathu, Northern Cape, South Africa. The participants were the N2 students that enrolled for Mathematics in the first and second trimester and were taught by the researcher. The case study used quantitative and qualitative research methods.

3.3 Research questions

The aim of the study was to gain in-depth understanding of N2 students' misconceptions relating to Algebra, as well as their perceptions of strategies to address the misconceptions through the use of screencasts. The research questions for this study are:

- What were the N2 students' misconceptions relating to Algebra?
- To what extent could students' misconceptions be addressed by using screencasts in order to increase their metacognitive skills when learning Mathematics concepts?

3.4 Research methods

3.4.1 Mixed method research

The research method used to answer the research question will be a mixed method. A mixed method methodology presents a logical and insightful appeal, therefore it presents a platform for connecting the gap between qualitative and quantitative paradigms. A researcher can use one method to overcome limitations in alternative method and hence have stronger evidence and confirmation for hypotheses or the problem. Using both qualitative and quantitative data in a study can, consequently, produce a more inclusive and complete understanding vital to inform decision making. Mixed methods also enables researchers to concentrate on a comprehensive and a more clear variety of research questions since they are not restricted to one method. Quantitative research enhances the validity of research instruments as well as provides a numerical measurement to investigate and study phenomena. In addition, quantitative studies can simplify human understanding, statistically, making the study of research findings straightforward. Qualitative studies, on the other hand, take into account the lived experiences hence allowing contextualisation of the examination of phenomena. They allows for an in-depth understanding of phenomena since they are often planned, organised and controlled data collected over a long period of time. Therefore the reasons for the convergent of the approaches are to obtain a more thorough understanding from two methods and validate results from numerous methods and procedures (Creswell, 2012; De Vos et al., 2011; Fraenkel et al., 2012; Maree, 2007; McMillan & Schumacher, 2014; Tashakkori & Teddlie, 2002a). Figure 3.2 depicts the procedure that the researcher followed during data analysis.

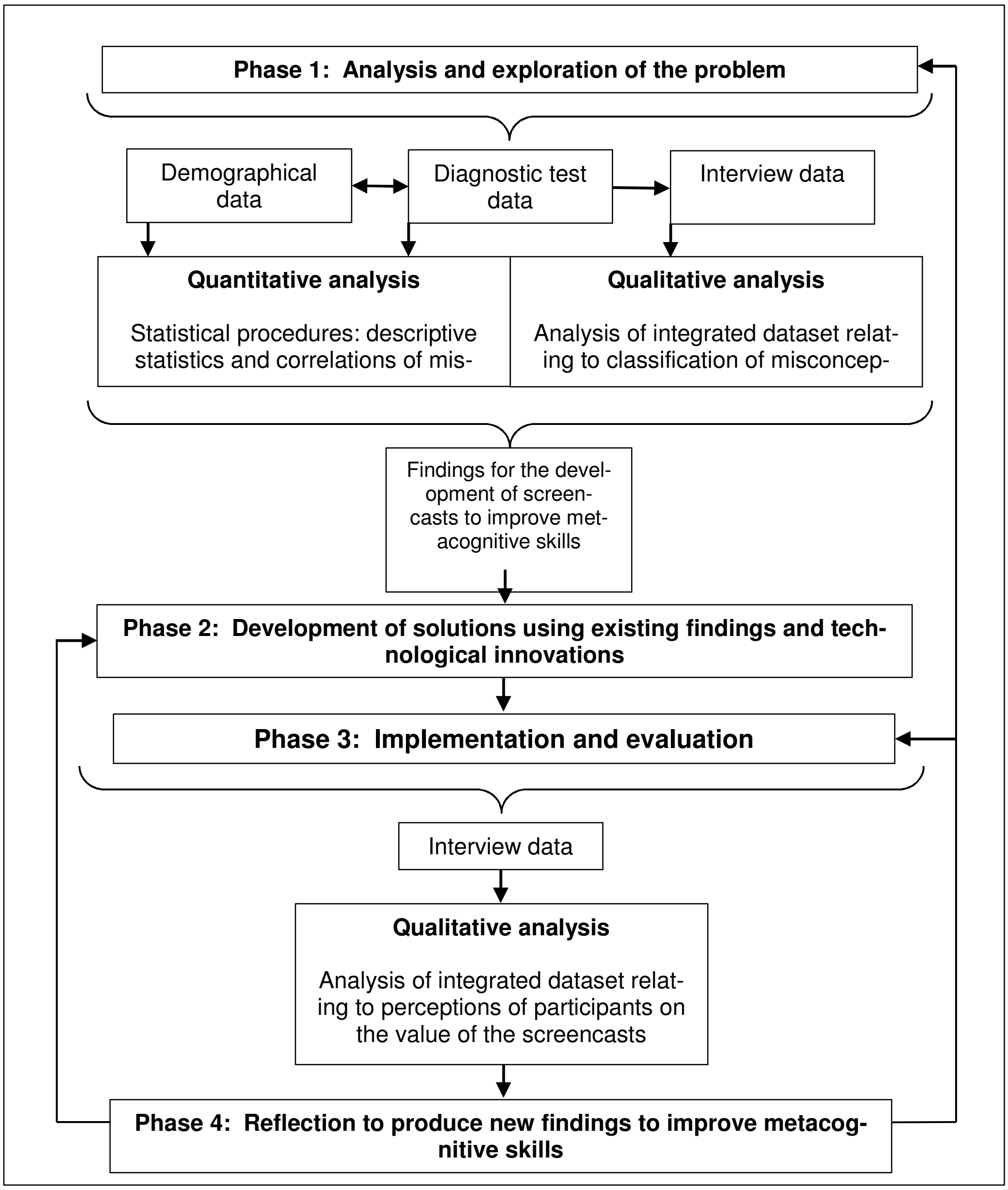

Figure 3.2: Research procedures followed during this study

Phase 1 will be discussed in Chapter Four, phases 2 and 3 will be discussed in Chapter Five and phase 4 will be discussed in Chapter Six as a concatenation of the results and a reflection on the process.

3.4.2 Quantitative Research

Quantitative research is a formal, objective, systematic process in which numerical data are used to obtain information about the world. A quantitative research method is used to describe variables, to examine relationships among variables and to determine cause-and-effect interactions between variables (Burns & Grove, 2005). This quantitative descriptive study will consist of four steps:

Step 1: Analysis of data from a diagnostic test for identifying misconceptions

Step 2: The researcher developed screencasts based on identified misconceptions

Step 3: The research participants consequently evaluated the screencasts with the assistance of a questionnaire

Step 4: Analysis of data and reflection to produce guidelines that could enhance the design, development and implementation of screencasts to promote metacognitive skills.

Therefore, the first phase of the study comprised a diagnostic test to determine the participants' misconceptions relating to Algebra. The researcher compiled a customised in-depth diagnostic test in order to uncover particular strengths, weaknesses and difficulties that a participant experienced. The instrument was designed to expose causes and specific areas of weakness or strengths of the participants' understanding of the Mathematics concepts (Cohen, Manion, & Morrison, 2007). During the second phase (Figure 3.2), the researcher produced screencasts relating to the identified misconceptions. The third phase comprised a questionnaire for participants who used the screencasts. The researcher analysed the data and evaluated the screencasts. During the last phase of reflection the guidelines were refined (Figure 3.2).

3.4.3 Qualitative Research

Qualitative research focuses the study on the experiencing of social actions. Qualitative data are displayed as text, an alternative to numbers and statistics. The researcher employed certain strategies to understand the meaning and implications which the research participants attached to their learning (Wellman et al., 2005.p.6-8). This qualitative part of the study comprised an analysis of the misconceptions of research participants in phase one, as they emanated from the interviews with ten students. The students were asked to explain the way they think and the different steps they used in writing the diagnostic test. The interviewer chose a setting with the least distraction, explain the purpose, address confidentiality, explain the format of the interview and prepare a method for recording the data. In phase three qualitative research methods were used in the analysis of integrated datasets relating to the opinions on the value of the screencasts. The students complete a survey on what they thought on the screencast.

3.5 Targeting of research participants

A population is the total of persons, procedures, organisation units, or other sampling elements with which the research problem is concerned (Lehtonen, 2011, p. 194). A population includes the entire collection of all components of study about the researcher requirements to make detailed assumptions (Wellman et al., 2005). The larger group to which one hopes to refer the results is called the population (Fraenkel & Wallen, 2008).

The population of this study related to was the full time N2 students of the Campus. The minimum requirements for becoming an artisan is a N2 certificate comprising four subjects, one of which is Mathematics (Pretoruis, 2011). The normal time to complete Nated level courses, as determined by the Department of Higher Education, is ten weeks of study for full-time students. At the Kathu Campus, the N2 courses are offered as full-time or part-time with face-to-face classes, followed by an examination period. The courses comprise a total of sixty contact hours for the ten-week period. On average, six contact hours per week are allocated to the various courses, and then followed by two weeks of examination. The students write two tests during the ten week period, a tests in week four and in seven or eight. The first test represents thirty per cent and second test represent seventy per cent of the term mark. Figure 3.3 illustrates the seven step processes to be followed to become an artisan. Step 2, the theoretical training, takes place at the college and is the focus of this study.

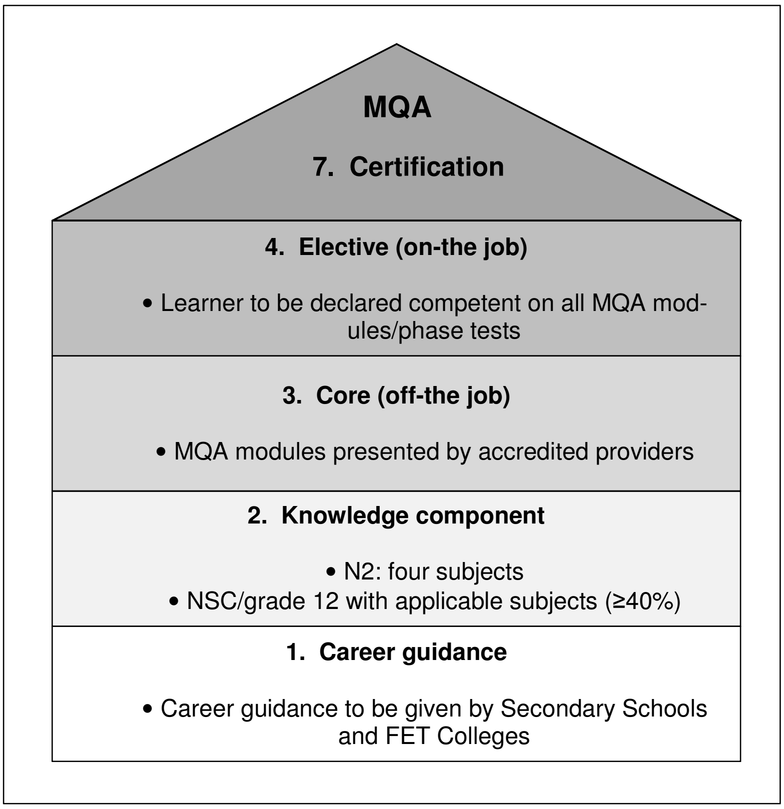

Figure 3.3: Adapted version of seven step artisan training process (Pretorius, 2011)

Students have to comply with certain pre-requisites to enrol for the following choices of trades offered at Kathu Campus: Electrical N2, Millwright N2, Fitter N2, Plating N2 and Diesel N2-trade. The requirements for enrolment are as follows:

- grade 12 certificate with Mathematics and Physical Science marks not below forty per cent
- passed the Technical Test Battery (TTB) conducted by one of the regional mines
- passed N1 with Mathematics and Science
- NCV L4 with forty per cent for Mathematics (Pretorius, 2011).

3.5.1 Research participant selection

The researcher used a non-probability sample, which means the researcher targeted a specific group, with detailed knowledge that may not represent the broader population. During a non-probability sampling, participants are selected for a clear purpose (Cohen et al., 2007). It represents only the research sample (Cohen et al., 2007). The selected sample was the N2 full time students at Kathu Campus that enrolled for trimester one and two in 2013.

All students in the cohort were invited to participate in the study. The students who did not want to participate in the study completed the assignment with the other students, but their answers were excluded from the study. During non-probability sampling the odds of selecting a particular individual are not known (Lehtonen, 2011) as the researcher did not know how many students were going to enrol or participate. The number of enrolments depends on the mines, Transnet, businesses, as well as some private students.

3.6 Data collection techniques

Both quantitative and qualitative methods were used during data collection of this study. Tests are a technique that is used to collect empirical research data (Tashakkori & Teddlie, 2002a). This study used three methods of data collecting: (i) a customised diagnostic test (Addendum 3.1), (ii) a questionnaire (Addendum 3.2), and (iii) an interview (Addendum 3.3).

3.6.1 Quantitative data collection techniques

Diagnostic testing is an in-depth test to discover particular strengths, weaknesses and difficulties that students experience, and is designed to expose causes and specific areas of weakness or strength (Cohen et al., 2007). The diagnostic test that was used to determine the misconceptions of students included several items about the same feature, so that several types of difficulties in a students' understanding could be exposed. The customised diagnostic test was in the format of closed-ended questions, where only one answer was correct. The test used was part of a test set by Phillip Swedosh. The original test comprised twelve questions and was a subset of seventeen questions (Swedosh & Clark, 1998). The questions that were eliminated for the purpose of this study were those that dealt with content which did not form part of the students' Mathematics curriculum. Each question was designed in such a way that if the student had a particular misconception, it would become apparent when considering the response of that student to the question. In phase one the test was given to the students one week before the end of the trimester; and in phase two the test was given the first day of the second trimester.

For a test to be useful, it must be both reliable and valid. Reliability is an indication of how precise the measurement is, or how consistently the test measures what it should measure (Leedy & Ormrod, 2010). Validity is the ability of the test to measure what it is intended to measure, or the accuracy. Validity is not a quality that can be established in a single measurement, but is accumulated via several measurements (Leedy & Ormrod, 2010). Content validity was established by presenting the test and objectives to an independent panel of experts to ensure that the domain was adequately covered. The tests included a section on demographics developed in collaboration with subject experts and the Statistical Consultation Services of North-West University, Potchefstroom campus (Addendum 3.2).

The questionnaire in phase one was a self-administered questionnaire, meaning that the researcher was present (Cohen et al., 2007). The information and evidence of the questionnaire were used to compile the profile of the students, to compare the sample and decide if the same mathematical misconceptions are demonstrated by certain samples (Maree, 2007). The questions were a mixture of completely open and closed-ended items. The closed-ended questions required that the students completed the same questionnaire. Each question provided a choice of possible responses from which the students must select one correct option (Tashakkori & Teddlie, 2002b). In addition, a single item may also be mixed, meaning that the student can select a possible answer or fill in a different answer. The other category allowed students to fill in their own words (Tashakkori & Teddlie, 2002b). Data were collected by the questionnaires, using quantitative methods. The quantitative methods were used to collect data relating to the demographical information of the students and the number of students who took part in the research. The questionnaires were given to the students in the beginning of phase one. The questionnaire presented the same questions for all the students and ensured anonymity (McMillan & Schumacher, 2001).

At the end of the trimester (Phase 3, Figure 3.2) 23 students were asked to fill in a questionnaire regarding the screencast they had watched. They were given options to respond about the screencasting videos. The questionnaire comprised open-ended questions and closed-ended questions.

3.6.2 Qualitative data collection techniques

3.6.2.1 Individual interviews

The purpose of qualitative interviews in this study was to see the world through the eyes of the student. The method of interview was one-on-one, personal interviews. An interview is a two-way discussion in which the interviewer asks the participant questions to gather information and to study concepts, principles, opinions and conducts of the students (Maree, 2007). In the study, I used semi-structured interviews (Addendum 3.3) to discover students' thinking processes. At the beginning of each interview, I explained the objectives of the study to the participants, and what was expected from

them. Participants for interviews were selected according to the highest number of misconceptions displayed during the diagnostic test.
The students were given an opportunity to say out loud what they were thinking. When selecting the ten students for phase two for interviews, I decided to interview students who represented the six highest categories of misconceptions that I identified under each theoretical area. The areas were exponential laws, solving equations and factorisation. During the interview, participants were encouraged to explain what they were doing as they tried to solve the problem. Each interview lasted from five to fifteen minutes. The interviews were voice-recorded and later transcribed *verbatim*.

The first four interviews were a disaster; the participants could not explain what they were doing and why they were doing it. From the fifth interview I changed the methodology. The participants first had to complete the diagnostic test and then explain their methods in their own words. At the end of the interview, I thanked them for their written work. During the analysis stage, I listened to the interviews and simultaneously reviewed the test data.

3.7 Data Analysis

3.7.1 Quantitative data analysis

Data analysis in quantitative studies does not in itself suggest the answers to research questions. The answers are found by way of analysis of data and the outcomes (De Vos, Strydom, Fouche, & Delport, 2007). The measurement level of the data was nominal because it was classified into categories of sex, gender, race, home language, province and technology use. The age was in ratio levels of measurement. Numerical values were given to the data to calculate statistics. Descriptive data analysis was used. The data were analysed by the Statistical Consultation Services of the North West University (Potchefstroom campus) using the Statistical Package for Social Scientists (SPSS). The following techniques were included:

- Descriptive statistics of biographical information: frequencies and percentages
- Descriptive statistics of misconceptions: frequencies and percentages.

3.7.2 Qualitative data analysis

The qualitative data from the interviews were analysed with Atlas.ti™, a computer-based program that allows researchers to bring together text, illustrative, audio, and visual data files, along with coding (Creswell, 2009). Six steps were used in analysing the qualitative data:

- Step 1: Organise and prepare the data
- Step 2: Read through all the data
- Step 3: Detailed analysis with a coding process
- Step 4: Use the coding to generate a description of misconceptions

- Step 5: Advance how the description and misconceptions will be presented
- Step 6: Interpretation of the data.

The integrated dataset embedded in Atlas.ti™ is available as (Addendum 3.4)

3.8 Validity and reliability

Validity in research has to do with the exactness and frankness of scientific findings. A valid research study should reveal what truly exists and a valid instrument or measure should truly measure what it is supposed to measure. Validity is the point to which an instrument measures that which it is supposed to measure and succeeds at what it is designed to achieve. As a process, validation involves gathering, examining and studying data to measure the accurateness of an instrument (Creswell, 2009; Fraenkel et al., 2012; McMillan & Schumacher, 2014; Tashakkori & Teddlie, 2002b; Wellman et al., 2005).

Reliability has to do with the consistency, stability and repeatability of the participants' descriptions as well as the researchers' capability to accumulate and document data truthfully. It refers to the ability of a research method to yield regularly the same outcomes over repeated testing periods. In other words, it requires that a researcher using similar or comparable methods must obtain the same or comparable results every time he uses the techniques on the same or similar subjects (Fraenkel et al., 2012; McMillan & Schumacher, 2014; Wellman et al., 2005).

3.8.1 Validity and reliability in quantitative research

Validity in quantitative research often concerns: fairness, generalisability, reliability, probability and controllability and nomothetic reports. Internal (contextual) validity, as it is called in quantitative research, is one of the most important indicators of validity. In quantitative research, the eventual question is whether we can obtain, and get effective assumptions and answers from a study given the research design and controls employed. A central question is how the theory has been built based on previous studies. External validity is an important principle in quantitative research. External validity is the degree to which the outcomes of research can be generalised from a sample to a population. Founding eternal validity for an instrument, then, follows straight from sampling. A sample should be a correct representation of a population, because the entire population may not be accessible. An instrument that is externally valid helps obtain population generalisability, or the degree to which a sample characterises the population (De Vos et al., 2011; Maree, 2007; McMillan & Schumacher, 2014; Wellman et al., 2005).

Reliability generally refers to the degree to which a variable or set of variables is reliable in what it is planned to measure. When numerous measurements are taken, the reliable measures will all be consistent in their standards. Lack of reliability refers to accidental or chance error. If measurement results are not dependable and consistent, it becomes more problematic and risky to test hypotheses or to make suggestions about the associations between variables in quantitative research. Threats to consistency during data collection include the following: a lack of clear and standard directions, measurement instruments describe items vaguely so that they are misunderstood, abstract theories are not measured with enough indicators of identical kind and management circumstances differ, absence of pretesting, the questions are not presented in the proper sequence, the questionnaire is too lengthy or problematical to read, and the interview is too time-consuming. Failure to answer questions, giving numerous answers to the same question and remarks in the margin may all indicate lack of reliability. Random sources of error, such as misprints and other errors in data collecting, may threaten reliability at all stages of research progression (Cohen et al., 2007; Creswell, 2009; Fraenkel et al., 2012). The instrument used in this study was based on the test Swedosh used in his studies(Swedosh, 1994). The original test had seventeen question but this case study used twelve questions that were approved by a panel of Mathematic Academics of North West University in Potchefstroom.

3.8.2 Validity and reliability in qualitative research

Validity in qualitative research often concerns: trustworthiness, productivity, reality, scope, bias, individuality and idiographic reports. In qualitative research, contextual validity refers to the trustworthiness of case study data and the assumptions drawn. Limitations to the internal validity of quantitative work may occur during the research. A good research design is always of vital importance when pursuing high internal validity. During research design, the threats to internal validity contain inadequate knowledge of, or paradoxes, in the reasoning. However, shortcomings in the later stages of research—i.e., during data collection, examination and/or clarification and understanding—can also indicate studies with low internal validity. During data collection, potential threats to internal validity are many, including, for example, instrumentation problems. Instrumentation issues occur when scores generated from a measure lack the suitable level of reliability or do not generate valid scores. Researcher bias means that the researcher has a particular bias in favour of one procedure over another. Errors in statistical testing, deceptive correlation and fundamental errors are some examples of threats during data examination and analysis (McMillan & Schumacher, 2014; Tashakkori & Teddlie, 2002b).

In qualitative research, technical reliability is connected to dependability, characteristically meaning that another person should be able to study the work and come to similar assumptions and answers.

Meticulous recording and commentary should allow the reader to measure how the researcher has gathered, produced and understood the information (Maree, 2007; Wellman et al., 2005).

Content validity refers to the suitability of the content of an instrument. This is essential with achievement tests. This would include taking representative questions from each of the divisions of the unit and weighing them against the chosen results. Reliability is directly related to the validity of the measure. A test can be considered reliable, but not lawful or valid. It is a reliable test, though only a moderately valid indicator of achievement ,due to the lack of planned setting—class attendance, parent controlled study, and sleeping habits—each holistically connected to achievement (Cohen et al., 2007; Creswell, 2009). In this case study the set of open ended questions was used, also based on the work of Swedosh (1994). The set of questions was approved by the ethics committee of North West University.

3.9 Ethical Issues

Ethical clearance was obtained from the Ethics Committee of the North-West University, Potchefstroom campus (Addendum 3.5). Permission was obtained from the NCR FET College CEO, and the campus manager of Kathu Campus to continue with the study (Addendum 3.6). The researcher requested the students' permission for participation in the study:

- Participants were informed that their participation would be appreciated, but participation was voluntary. Students had the right to withdraw from the research at any time, without fear of being penalised. Their responses were regarded as confidential and any publication as an outcome of the survey would not identify any individual in any way.
- Students not taking part in the study would continue with contact sessions as usual, but the researcher would not use their responses as data in the study.
- Written informed consent was obtained from the participants.
- Guarantees of confidentiality were given to the participants (Cohen et al., 2007) (Addendum 3.7).

3.10 Contribution of the study

The study formed part of the project *Using Information Communication Technologies (ICTs) in teaching and learning in an Open Distance Learning (ODL) programme* in the research programme Technology Enhanced Learning for Higher Education at the Faculty of Education Studies of the NWU. It contributed to the understanding of the use of screencasts as cognitive tools in an authentic learning environment.

3.11 Summary of the chapter

This research used case study approaches as the general design. It aimed to uncover N2 students' misconceptions in Algebra. A sequential explanatory design was applied and this was characterised by the collection and study of quantitative data followed by the collection and study of qualitative data. The main research method in the quantitative phase was a diagnostic test while interviews served as the aim of the main research in the qualitative phase. Students' responses to the diagnostic test, their interview transcriptions, were concurrently used as multiple data sources to reach valid assumptions about student misconceptions. The participants completed a questionnaire regarding the screencast they viewed and provides their opinions about the screencasting videos.

From the pragmatic point of view, through action, it is possible to attain knowledge focused on behaviour. The challenge to educators is to use the experiences they obtain from teaching-learning activities to understand the learning problems of their students and use their understanding to the benefit of their students. Thereby, researchers engage in the *for education* style to advance teaching and learning while using technology to enhance the process (Burrel & Morgan, 1979).

Chapter Four

Phase 1 analyses of integrated qualitative and quantitative data

4.1 Introduction

The aim of this research was to identify N2 Nated Engineering students' misconceptions relating to conceptual fields within Algebra, and assess those using metacognition. This chapter discusses the misconceptions identified as conceptual areas. Finally, the researcher reflects on the patterns of students' misconceptions and findings as recommendations to be used in further development of technological applications and instructional practices. The students as research participants shared several common misconceptions during the Algebra diagnostic test and the analysis provided insight into the misconceptions and the reasons for them. Combined quantitative §3.4.2 and qualitative §3.4.3 methods contributed towards the data of this analysis.

4.2 Research instrument

Phase 1 of the study comprised three research instruments: (i) an open-ended question, requesting the students' demographical information (Addendum 3.2), (ii) a customised diagnostic test of twelve questions in which students had to demonstrate all the steps of their thinking (Addendum 3.1), and (iii) interviews (Addendum 3.3) with identified students because they demonstrated the most misconceptions during the diagnostic test.

4.3 Descriptive statistics of biographical information

Section A of the customised concept test (Addendum 3.1) included eleven questions to collect the biographical information of the respondents (Groups 1 and 2, N=113) who completed the test. Table 4.1 provides the frequencies and percentages (rounded off to the nearest whole number) of the biographical data: age, gender, cultural background, home language, language of instruction, province of birth, residing province, mining company apprenticeship, level of education, access to devices, and access to Internet (Addendum 4.1).

Table 4.1: Frequencies and percentages of the biographical information (N=113)

Question	Biographical information		Frequencies	Percentages
2.1	Age	≤24	50	44
		25-34	9	8
		35-44	1	1
		Not specified	53	47
2.2	Gender	Male	92	81
		Female	19	17
		Not specified	2	2
2.3	Cultural background	Black	54	46
		Coloured	37	33
		White	21	19
		Other	1	2
2.4	Home language	Afrikaans	52	46
		English	6	5
		Setswana	50	46
		Other	5	4
2.5	Language during learning	Afrikaans	46	31
		Other	101	69
2.6	Province of birth	Eastern Cape	1	1
		Gauteng	12	11
		Limpopo	3	3
		North West	17	15
		Northern Cape	74	65
		Western Cape	6	5
2.7	Residing province	Eastern Cape	1	1
		Limpopo	1	1
		North West	12	11
		Northern Cape	90	80
		Western Cape	3	3
		Not specified	5	4
2.8	Financial aid	Yes	59	52
		No	54	48
2.9	Access to devices	Mobile phone	100	33
		Tablet with Internet	4	1
		Tablet without Internet	21	7
		Laptop with Internet	26	9
		Laptop without Internet	15	5
		Desktop with Internet	12	4
		Desktop without Internet	19	6
		DVD player	49	16
		Memory stick	57	19
2.10	Place of access	At home	52	35
		Public library	19	13
		Internet café	30	20
		Anywhere on mobile device	48	32

4.3.1 Age

Although most of the respondents (47%) did not specify their age, 44% were younger than 24 years old. A smaller percentage of the respondents (8%) were between the ages of 25-35, and only one per cent (1%) of the respondents older than 35 (Table 4.1).

4.3.2 Gender

The majority of the respondents (81%) were male and only 17% were female (Table 4.1). For 2013, Statistics South Africa proposed a South African population of almost 53 million (SA

Statistics, 2011), of which about 51% the residents are females. The Northern Cape, the smallest portion of South African population, also presents 51% female residents (Darling-Hammond, Austin, Cheung, & Martin, 2009b). However, at the Kathu Campus these statistics are not reflected in the same way in this field of study (Darling-Hammond et al., 2009b). The reason for the large variations in the gender is that the engineering field of study was historically a "man's" job. With the equalization of woman and men, the field is starting to open up for women. Initiatives like "Women in mines" is starting to show results to increase the number of women trained to be artisans, engineers, operators and other professions historically done only by men. South Africa is possibly ahead of other major countries dedicated to mining in terms of bringing women into the mining labour force (Swedosh, 1999).

4.3.3 Cultural background

The main cultural group represented in this study was Black (46%), with Coloured (33%) as the second largest cultural group in the study, and 19% of the study group was White (Table 4.1). The South African population presents about 42 million Blacks (80%); Whites and Coloureds are less than five per cent (4,6 and 4.7 million respectively), and Indians 1.3 million (SA Statistics, 2011). In the Northern Cape the population constitutes 33% Black, 52% Coloured, 13% white, and 0, 3% Indian (Darling-Hammond et al., 2009b). The population representation at Kathu Campus is in contrast with South Africa's population (Acevedo, 2008).

4.3.4 Home language

The Northern Cape Province is a predominantly Afrikaans-speaking region (Acevedo, 2008). Equal numbers of Afrikaans and Setswana speaking respondents (46%) were part of this group, even though the majority of the respondents (52%) came from the Coloured and White population groups (Table 4.1).

4.3.5 Language during learning

Afrikaans is the principal language in the Northern Cape Province; 54% of the residents in the province speak Afrikaans and 33% of the population speak Setswana. Most respondents (69%) speak a language other than Afrikaans when they study, even though they receive their education mainly in Afrikaans and in English (Table 4.1). The medium of instruction at Kathu Campus is Afrikaans and/or English. No technical textbooks are available in the other indigenous languages like Setswana. Classes are presented as dual-medium in Afrikaans and English, with the emphasis on Afrikaans (Figure 4.1).

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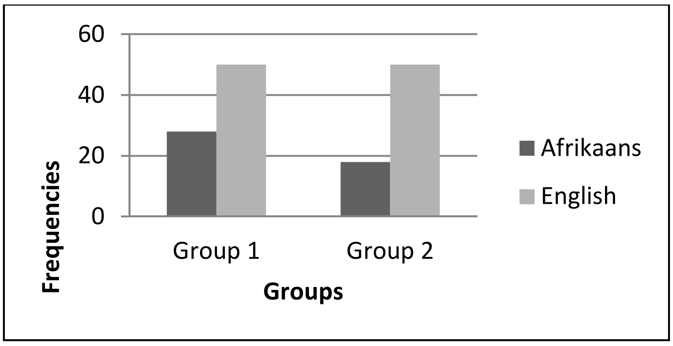

Figure 4.1: Teaching language at the Kathu Campus for N2 Mathematics students

4.3.6 Province of birth

The majority of the respondents (65%) were natives to the Northern Cape Province and 15% were born in the neighbouring North West Province (Table 4.1).

4.3.7 Residing province

Most of the respondents (74%) lived in the Northern Cape Province. Only ten per cent of the respondents resided in the neighbouring province (the North West province) of the Northern Cape (Table 4.1).

4.3.8 Financial aid

About half of the respondents (52%) received financial aid from external service providers, and 48% of the respondents were themselves responsible to pay their course fees (Table 4.1).

4.3.9 Access to devices

About a third of the respondents (33%) had access to a mobile device, nineteen per cent (19%) had a memory stick on which to download their teaching and learning material and few had access to either a tablet with (1%) or without (7%) access to the Internet. Only six per cent had access to a desktop computer (Table 4.1).

4.3.10 Place of access

The respondents who had a mobile device (33%) had the option to access the Internet and therefore were able to access the Internet from home; 32% indicated they accessed the Internet wherever they were, and twenty per cent (20%) visited an Internet café when they needed to use the Internet (Table 4.1).

4.4 Misconceptions

As explained in § 3.4.2 and § 4.2 the customised concept test (Addendum 3.1) included twelve Mathematics problems which the respondents had to complete. After evaluating the results from the test, several possible misconceptions were identified which the respondents had encountered during the formal test (Addendum 4.2). The researcher in collaboration with two Mathematics lecturers from the North-West University scrutinised the list of misconceptions which related to each question in the diagnostic test. Several misconceptions were repeated in more than one of the questions (Addendum 4.2), therefore one central misconception was identified in each question. Table 4.2 provides the list of the central misconception in the twelve test questions.

Table 4.2: Analysis of twelve questions in order to identify central misconceptions

Question number	Central misconception	Frequency	Percentage
1	Simplification of fractions	14	2
2	Division and simplification of fractions	38	6
3	Understanding of index laws	20	3
4	Application of index laws	94	14
5	Over-generalisation of index laws	32	5
6	Square roots and index laws	50	7
7	Solving quadratic equations through factorisation	56	8
8	Application of elimination methods in equation solving	64	9
9	Zero-product rule	59	9
10	Application of factorisation	77	11
11	Switch of denominators, numerators, and changing of signs	93	13
12	Factorisation of two square roots	90	13
	Total:	687	100

After the analysis of the diagnostic test, the researcher identified the three core Mathematics concepts which were repeated in several of the diagnostic test questions: (i) index laws, (ii) equations, and (iii) factorisation. The researcher performed a walk-through with 113 respondents (i) to confirm the analysis of the diagnostic test, and (ii) to determine how the respondents thought about their own learning. Vygotsky (1978) advocated that students should verbalise their thought processes during completing a task in order to make sense of a problem and also to become aware of their thinking and learning processes. The researcher aimed to understand the metacognition (§ 2.4.2) of the respondents with the use of the interview (§ 3.4.3). The following section provides a comprehensive summary of: (i) the three misconceptions identified during the diagnostic test, (ii) the percentages of correct answers and misconceptions relating to the twelve central misconceptions, and (iii) the findings from the deductive analysis of the walk-through with the ten respondents to confirm the three central misconceptions and to experience how the respondents verbalise their thought processes and learning processes. A graphical overview of the qualitative findings from the walk-through methodology is available as Figure 4.2.

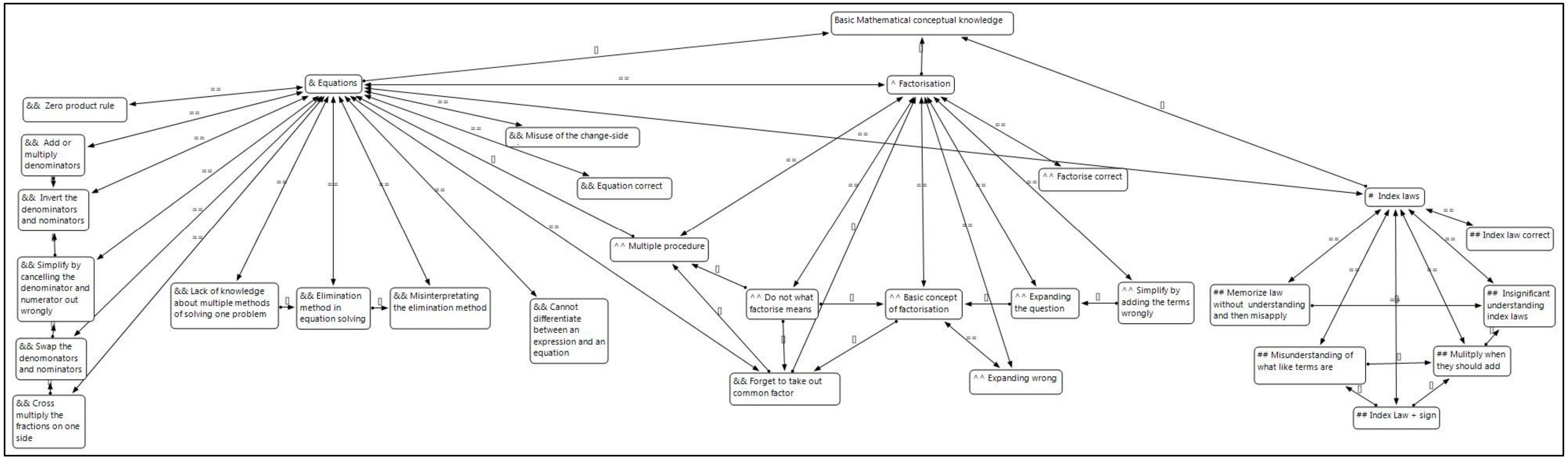

Figure 4.2: Participants' explanations of their Mathematics misconceptions

4.4.1 Misconception 1: Index laws

Question 4 in the test of groups 1 and 2 (Table 4.1) shows that 35.4% of the participants selected the answer 4^x. The answers of 2.2^x or 2^{x+1} were accepted as correct responses to this question. Nevertheless, $2^x + 2^x = 4^x$ *and* $2^x + 2^x = 2^{x^2}$ were the two most common misconceptions. Inadequate or erratic understanding of index laws is evident here. As explained in § 4.3, several of the misconceptions were identified in more than one of the twelve questions. Table 4.3 gives a summary of the percentages of correct answers and the misconceptions regarding index laws derived from the twelve central misconceptions in Table 4.2.

Table 4.3: Summary of percentages of correct answers and misconceptions* of index laws in questions 3, 4, 5 and 6

Question	MC 3	MC 4	MC 5	MC 6
Answered correctly	81%	3%	69%	55%
Misconception	19%	97%	31%	45%

* Misconceptions (MC)

Table 4.3 indicates that 97% of the respondents were not able to apply index laws during problem solving (Addendum 4.3). Question 1 of the interview questions (Table 4.4) was the same type of question, but the base was changed. None of the ten interviewed participants could provide the correct answer. During the interview the misconception could again be divided into two misconceptions, $3^x + 3^x = 3^{x^2}$ *or* 3^{2x} and $3^x + 3^x = 6^x$. In the first case, the participants misapplied the law as they regarded the base the same and multiplied the indices or added the indices. In the second case, the participants also added the bases, as well as added or multiplied the indices.

Table 4.4: Question 4 of the diagnostic test and question 1 asked during the interviews

Diagnostic question 4: Simplify	
$2^x + 2^x$	
Interview question 1: Simplify	
$3^x + 3^x$	

Figure 4.3 illustrates the possible misconception regarding the index law. Another misconception was the misunderstanding of what terms were.

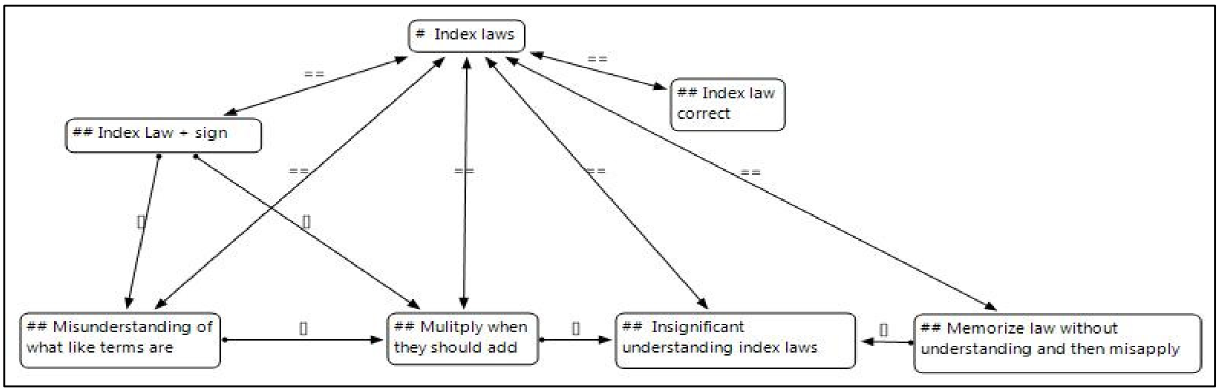

Figure 4.3: Misconceptions relating to index law

The participants focused on the index and did not take the positive sign (+) in the middle of the expression into account; or did not grasp that the two terms were similar and could therefore be added. Participants memorised the laws but they did not know what they meant, or where they were applied. When they identified an index question, they randomly used any of the laws and therefore misapplied the laws. Examples from the interviews illustrate the different misconceptions:

- I'll take the $3^x + x = 3^{2^x}$ (P1: 4).
- It tells me that I must add the indices
  $3^x + 3^x$
  $= 3^{x2}$ (P2: 5)[1].
- I added the indices and the bases $3+3=6$ and the answer was x^2 (P3: 6)[2].
- The question must be simplified. If the bases is the same and you want the indices, then you add the indices. The final answer is 3^{3x} (P4: 7)[3].
- If the base is the same you can add the indices. So the answer will be 3^{2x} (P5: 8).
- I add the two bases to each other it gave me 6 and the answer is then 6^x (P6: 9).
- Equally as you can see that is the $3^x + 3^x$ which means the bases are equal so we will say $3+3=6^x$ (P7: 10).

Participants 6 and 9 displayed the same misconception which let them add the base. Participant 6 multiplied the index. Participants 7 and 8 used one base but multiplied the index (Addendum 4.3). Participant 9 only wrote down x as solution to the problem·

1 Dit sê vir my ek moet die twee eksponente bymekaar tel

$3^x + 3^x$

$= 3^{x2}$ (P2: 5).

2 Ek het die eksponente bymekaar getel en die basisse bymekaar getel $3+3=6$ gee vir my x^2 (P3: 6).

3 Vraag moet vereenvoudig word. As jou basis dieselfde is en jy wil die eksponent hê dan tel jy die eksponente op. Finale antwoord is 3^{3x} (P4: 7).

4.4.2 Misconception 2: Equations

An equation can be viewed as a statement of two equal quantities. An equation has two sides which are alike or balanced and linked by an equation (=) sign (Dekyi, Minshall, & Tokwe, 2007a). Equations can be rearranged in order to find the value of the unknown number or the variable. Misconceptions regarding the equation sign are entwined into the index law and factorisation. Questions 6-11 in the customised diagnostic test (Table 4.5, Addendum 3.1) involve the solution of equations. One question (Question 10) is not an equation, but will be discussed in this category because of the common misconception, in which students deal with this type of question as if it were an equation.

Table 4.5: Question 6-11 that related to equations asked during the diagnostic test

Diagnostic test questions 6-11: Simplify	
$x^2 = 81$	
$x^2 - 4x = 0$	
$x^2 = x$	
$(x-1)(x^2-3) = 0$	
$\frac{x^2-1}{x-1}$	
$\frac{1}{x} - \frac{1}{b} = \frac{1}{a}$	

Table 4.6 gives a summary of the percentages of correct answers and misconceptions regarding equations derived from the twelve central misconceptions in Table 4.2.

Table 4.6: Summary of percentages of correct answers and misconceptions* of equations questions 6-11

Question	MC 6	MC 7	MC 8	MC 9	MC 10	MC 11
Answered correctly	55%	49%	42%	38%	28%	8%
Misconception	45%	51%	58%	62%	72%	92%

* Misconceptions (MC)

Participants' reactions to question 6 (Table 4.6) indicated that 45% of all participants demonstrated a misconception relating to equations. Three possible methods to solve the variable x are available as can be seen in Table 4.7. The most common answer was $x = 9$ (method 1).

Table 4.7: Three methods of solving question 6 relating to equations

Method 1	Method 2	Method 3
$x^2 = 81$ $x^2 = 9^2$ $x = 9$	$x^2 = 81$ $x = \pm\sqrt{81}$ $x = \pm 9$	$x^2 - 81 = 0$ $(x-9)(x+9) = 0$ $x = 9 or x = -9$

The participants of group 1 mostly selected method 1 in order to solve the equation. The participants applied the index law, indicating that their perceptions relating to the principle of when bases are the same, the index law underpins the answer. The participants who applied method 2 did not take the square root in the equation into account which resulted in two answers, where one solution is positive and the other negative. None of the participants used method 3.

Fifty per cent of both groups demonstrated a misconception relating to question 7. Fifteen participants provided the answers of $x = -2$ or $x = 2$. The misconception relates to factorisation, as the participants did not take out x as a common factor. They assumed the two terms were the difference between squares. Fifteen participants from the two groups provided the answer as $x = 4$. The misconception related to the application of the zero product rule. The participants did not take into account that $x = 0$ could also be a possible solution. Two participants in group 1 answered the question with $x \neq 0$ as a solution.

Question 9 was a cubic equation which has been partly factorised. The percentage of participants who had misconceptions of question 9 is 57% (Table 4.6) relating to the diagnostic test; 42% of the participants provided the correct answers of $x = 0, x = 3$ or $x = 1$. The participants' insufficient knowledge about multiple methods of solving a problem was the biggest misconception. Eight participants expanded the question and calculated the answer as $x^3 - 4x^2 + 3x = 0$, three expanded and factorised, but did not solve for x. The misconception was that the participants did not recognise that the question related to the solution of a variable—their basic concept knowledge of mathematics was insufficient. Nine participants demonstrated the zero product rule misconception. The interview question was $(x-2)(x^2 - 2x) = 0$ to which four participants provided the correct answer, while one participant expanded and factorised, but did not solve for x. One participant provided the answer of $(x - 2x)(2x - 2x)$ while trying to factorise by using the grouping method. The participant could not distinguish between an expression and equation. Examples of the explanations of the participants illustrated that there were not many misconceptions relating to question 9:

- I am first going to simplify
  $(x-2)(x^2 - 2x) = 0$
  $(x^3 - 2x^2)(2x^2 + 4x)$ (P1: 1)[4].

[4] Ek gaan dit eers simplify

$(x-2)(x^2 - 2x) = 0$
$(x^3 - 2x^2)(2x^2 + 4x)$ (P1: 1)4.

- Take the first bracket and multiply with the other one and that is how we simplify

$$(x-2)\left(x^2-2x\right)=0$$
$$=x^3-2x^2-2x^2+4x=0$$
$$=x^3-4x^2+4x=0$$
$$=x\left(x^2-4x+4\right)=0$$
$$=x(x-2)(x-2)=0$$
(P2: 5)[5].

- First of all I have 2 x^2 minus 2 x^2 in the first bracket plus $2x$ to the index of 4 minus $4x^2$ and took a common factor out (P3: 6)[6].
- I have taken the bracket and made it equal to zero. The first bracket is $x-2=0$, and it gives you $x=2$. The second bracket is $x^2-2x=0$, and you take out a common factor, then it is $x(x-2)=0$ and then you get $x=0$ of $x=2$ (P3: 7)[7].
- Take the first bracket and say $x=2$. Then go to the next bracket and look for the common factor which is x then take x out of the bracket and remain in the bracket with $x-2=0$. Then $x=0$ or $x=2$ (P4: 8).
- The first thing I did was to get rid of my brackets by multiplying the first term with the first term, the first term with the second term, the second term with the first term, and the second term with the second term. Then I put the like terms together and got x^3-4x^2+4x. Take out x as common factor. Simplify the brackets. Got an answer of x, $x-2$. Last step $x-2$ and brought over that means $x=2$. The three answers were $x=0$, $x=2$, $x=-2$ (P5: 9).
- As you can see now question number 2 here is $(x-2)(x^2-2x)$ but now we first multiply the inners with the first basically with first. We apply for him here so it basically expand, and as you could see we are going to say $x\times x^2=x^2$ and $x\times 2x=-2x$ and another one is equal to $-2\times x^2=-2x^2$ and $-2\times -2x=4x$ so therefore what we usually know about a brackets because here we have some brackets you that when there is a bracket the values of x are going to be 3 but here likely we have x where there is x it's a common factor there for you leave out common factor you say $x\left(x^2-4+4\right)=x$ and what you can say there simply you can definitely see that $x=0$ therefore you factorise what's inside the bracket you'll say $(x-2)(x-2)$ that's how you factorise and

---

[5] Die eerste een hakie vat en maal hom met die ander ene so gaan eers simplify. Om alles te vereenvoudig

$$(x-2)\left(x^2-2x\right)=0$$
$$=x^3-2x^2-2x^2+4x=0$$
$$=x^3-4x^2+4x=0$$
$$=x\left(x^2-4x+4\right)=0$$
$$=x(x-2)(x-2)=0$$
(P2: 5).

[6] Eerste plek het ek 2 x^2 min 2 x^2 in die een hakie gesit plus $2x$ tot die mag 4 min $4x^2$ en het 'n gemene faktor uit gehaal (P3: 6).

[7] Ek het elkeen van die hakies gelyk aan nul gestel. By die eerste hakie is dit $x-2=0$ en dit gee vir jou $x=2$. Vir die tweede hakie is dit $x^2-2x=0$ en as jy die gemene faktor uithaal dan is dit $x(x-2)=0$ en dan kry jy $x=0$ of $x=2$ (P3: 7).

therefore you will know that $x = 2$ and therefore you are going to have two values (P6: 10).

Question 8 was $x^2 = x$, and the correct method is demonstrated below. The solving of the variable and factorisation were both part of the answer. The participants had insufficient knowledge of multiple methods of solving a problem. Thirty eight per cent (38%) of the participants of groups 1 and 2 provided the correct answer and 52% demonstrated a misconception. The most common answer was $x=1$ and twelve participants provided an answer that related to the misconception of the zero product rule. Eight participants gave the answer $x = \sqrt{x}$ and nine gave $x = x^{\frac{1}{2}}$. The two answers were the same. The misconception was that they did not take out the common factor as they did not know what factorisation entailed. The participants used index laws when they should have used factorisation. The correct method for solving question 8 in diagnostic test was:

$$x^2 - x = 0$$
$$x(x-1) = 0$$
$$x = 0 / x - 1 = 0$$
$$x = 0 / x = 1$$

Question 3 of the interviewed questions was the same as in the diagnostic questions. Two participants had the answer correct, one gave the answer as $x = \sqrt{x}$, and two wrote $x^2 = x$. Examples with the interviewed participants illustrated the participants' various misconceptions:

- I want to get rid of that index. I want to get rid of the index. To get rid of the x, you put this side in a square root

  $x^2 = x$

  $x = \pm\sqrt{x}$ (P1: 5)[8].
- It is not possible to solve x there (P2: 9).
- Just wrote $x^2 \neq x$ (P3: 10).

[8] Ek wil ontslae raak van daai eksponent. Om ontslae te raak van die x jy sit dit hierdie kant om in 'n vierkantwortel

$x^2 = x$

$x = \pm\sqrt{x}$ (P1: 5).

Twenty eight per cent (28%, n = 32) of groups 1 and 2 got the answer to question 10 of the diagnostic test correct (Tables 4.8 and 4.10). Sixty eight per cent (60%) demonstrated misconceptions. Thirty participants only simplified, providing the answer of $x+1$. Although this is not an equation, it will be discussed in the category of equations, since students often deal with an expression such as this one as if it were an equation. They did not understand the difference between an expression and an equation. Nine participants gave the answer as $x=1$—some used the elimination method, but then eliminated the individual terms and did not factorise the terms (Table 4.8).

Table 4.8: Incorrect elimination method for solving question 10

Method 1	Method 2
$\frac{\cancel{x}^2-1}{\cancel{x}-1}$ $=x-1$	$\frac{\cancel{x}^2}{x}-\frac{1}{1}$ $=x$

Method 1: participants divided x^2 by x to get an answer of x, following index laws.

Method 2: x^2 minus x is equal to 1, and 1 minus 1 is zero. Misinterpretation of the elimination method and simplifying by cancelling the terms were illustrated here. The participants did not know the basic concept of factorisation and also demonstrated insufficient knowledge about multiple methods for solving a problem.

Question 4 of the interview questions (Addendum 3.3) showed that five respondents provided correct answers, three simplified the equation, and one provided an answer of -1.

Table 4.9: Question 4 of interview

Solve x:
$\frac{x^2-4}{x-2}$

Examples with the interviewed participants illustrated the different misconceptions:

- Simplify the question. See that it's a division sign so that means it's to be the difference between two squares

  $x^2-4=x-2$ and $x+2$ my next step will be I'll cancel up (P1:1).

- Must get x alone. Must divide the x with each other x^2 must be divide with the x minus 4 divided by 2, gives you 2. Have two answers. Have one as one answer and two as another one. That gives one minus two and an answer of negative one (P2: 6)[9].
- Firstly I will factorise the $x^2 - 4$ then you will have $x-2$ and $x+2$. At the bottom I have $x-2$ and will cancel it out with $x-2$ at the top. Then I have $x+2$. Then I say $x=2$ (P3: 8).
- x can go in itself once and can go in x^2 twice. Answer $x=-2$, $x=0$ (P4: 9).
- This is simple as you can see here there is a $\frac{x^2-4}{x-2}$ therefore you have said that when you divide them simply you are going to cancel the index 2 – 1 = x and at the other hand we are going to say $\frac{-4}{-2}$ therefore it will give you definitely a + 2 which of course when you move 2 to the right hand side we are going to say $x=-2$ (P5: 10).

Question 11 (Table 4.6) was the question which had the most demonstrated misconceptions of 83%. Twenty one of the participants answered $x = a + b$ as they swapped the denominators and numerators. Ten participants answered $\frac{ba - xa - xb}{xba}$. The participants did not understand the question—they simplified and consequently did not solve x. Nineteen participants in groups 1 and 2 answered the question correctly. Examples with the interviewed participants listed different misconceptions:

- With I am going to get rid of the fraction first. Take the denominator and multiply it with the numerator. Take the numerator and multiply it denominator, and cancel out. They cancel out.

  $\frac{1}{x} - \frac{1^{\times c}}{c} - \frac{1^{\times c}}{d}$

  $\frac{x}{1} - 1 = \frac{1c \times d}{d}$

  $x - 1 =$ (P1: 5)[10].
- First of all I will move the 1 over c to the other side of the equations and is than equal to the sign, and then I have 1 over x is equal to 1 over d plus 1 over c. Then I add the fractions 1 over d plus 1 over c I added the fractions and got $\frac{2}{cd} = \frac{1}{x}$. Flip both sides of the fractions. So that the answer is equal to x and is equal to $\frac{dc}{2}$ (P2: 6)[11].

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[9] Moet x alleen kry. Moet die x 'e deel met mekaar. x^2 met x deel los my met een x en minus 4 gedeel deur 2 gee vir jou 2. Het twee antwoorde. Het een as een antwoord en twee as die ander antwoord. Dit gee vir jou een min twee, gee jou min een as 'n antwoord (P2: 6).

[10] Ek gaan eers ontslae raak van die breuke. Jy vat die onderste noemer dan maal jy dit met die teller. Jy vat die teller dan maal jy dit met die noemer dan kanselleer daai twee mos uit (P1: 5).

[11] Eerstens het ek 1 op c oorgeskuif na die anderkant van die vergelyking en is gelyk aan teken dan het ek 1 op x is gelyk aan 1 op d plus 1 op c. Dan het ek die breuk 1 op d plus 1 op c bymekaar getel en het gekry

- I first got rid of the -1 over c, took it over equal sign and got $\frac{1}{x}$ is equal to $\frac{1}{d}+\frac{1}{c}$. And then the x multiply on the right-hand and then got $x=\frac{1}{c}+\frac{1}{d}$ (P3: 7)[12].
- I took out the numerator and then multiply by x at the other side and then I had x in $\frac{1}{c}$ then I had $\frac{1}{d}+\frac{1}{c}$ (P4: 8).
- What I firstly did, I cross multiplied. I got $\frac{1}{x}$ and $\frac{c}{d}$. What I did cross multiply again. So I got an answer $x=d$, so then to make x the subject I divided the equation with c on both sides. Final answer is $x=\frac{d}{c}$ (P5: 9).
- Now $\frac{1}{x}-\frac{1}{c}=\frac{1}{d}$ we definitely going to make an x the subject of the formula. Where you can say when you can move $\frac{-1}{c}$ to the other side it's going to be positive. Therefore we are going to say $\frac{1}{x}=\frac{1}{d}+\frac{1}{c}$ therefore we simply change the denominator to the numerator and the numerator to the denominator therefore the answer $x=d+c$ (P6: 10).

In summary, Figure 4.4 illustrates the relationship between the various misconceptions regarding solution of a variable. Other misconceptions were cross multiplying of fractions, cancelling of denominators and numerators, and insufficient knowledge about multiple methods of solving a problem.

$\frac{2}{cd}=\frac{1}{x}$. Ek het die breuke aan beide kante omgekeer sodat die antwoord gelyk is aan x gelyk aan DC op 2 $\frac{dc}{2}$ (P2: 6).

[12] Ek het eerstens ontslae geraak van die -1 op c en dit oor die is gelyk aan teken gevat en gekry $\frac{1}{x}$ is gelyk aan $\frac{1}{d}+\frac{1}{c}$ en dan die x maal aan die regterkant dan gaan jy kry $x=\frac{1}{c}+\frac{1}{d}$ (P3: 7).

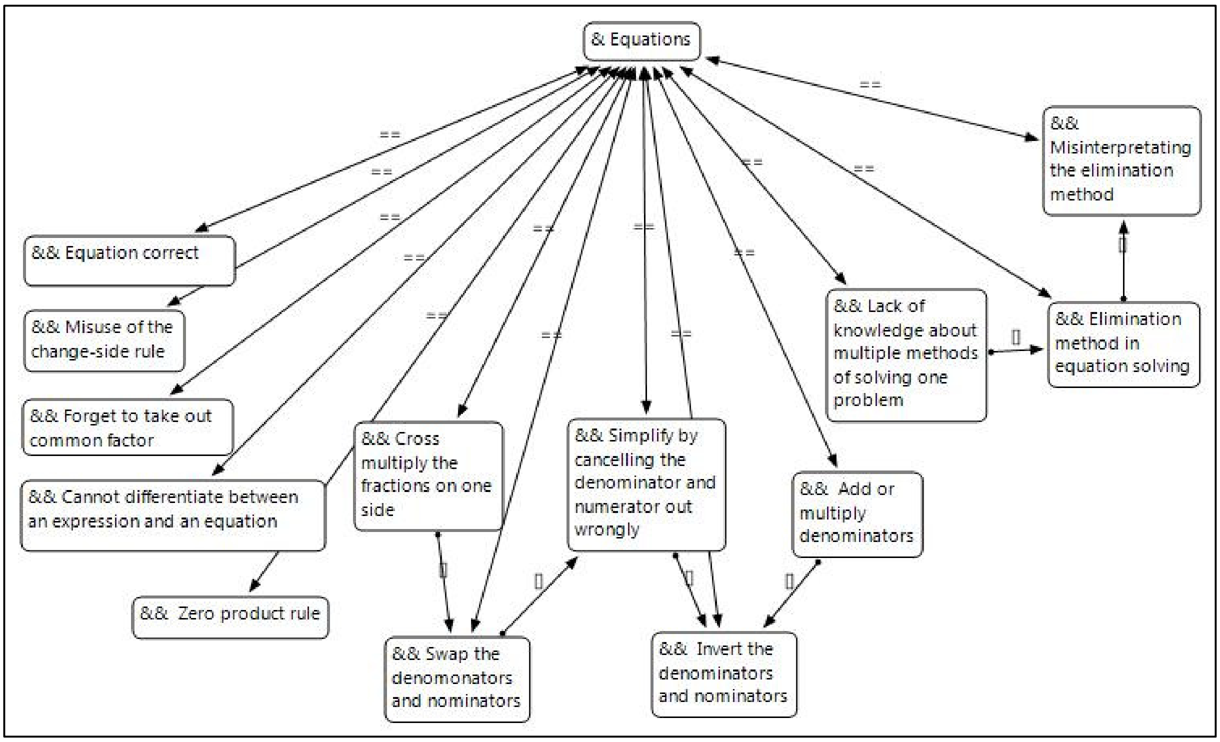

Figure 4.4: Misconceptions relating to equations

4.4.3 Misconception 3: Factorisation

Factorisation forms an important part of Algebra. Factorisation is used to solve variables, simplifying, and in functions to determine intercepts. Question 12 tested the difference between two squares and 92 of the 113 (81%) participants demonstrated a misconception regarding the differences between two squares. Twenty one (21) participants provided the correct solution of the problem of $(3x+y)(x+y)$; 26 participants provided the answer of $3x^2+4xy+2y$, where they expanded the question and did not understand the basic concept of factorisation. Table 4.10 gives a summary of the percentages of correct answers derived from the twelve central misconceptions regarding factorisation in Table 4.2 (Addendum 4.3).

Table 4.10: Summary of percentages of correct answers and misconceptions* of factorisation in questions 1, 2, 6, 7, 8, 9 10 and 12

Question	MC 1	MC 2	MC 6	MC 7	MC 8	MC 9	MC 10	MC 12
Answered correctly	82%	65%	55%	49%	42%	38%	28%	19%
Misconception	18%	35%	45%	51%	58%	62%	72%	81%

* Misconceptions (MC)

The majority of the respondents (81%) struggled to factorise two square roots, whereby they had to understand factorisation and apply the different methods of factorisation (Addendum 4.2). Question 6 of the interviewed questions was basically the same as I, only changed x and y to a and b. None of the interviewed participants got the answer correct. Three used this as step one $2^2a^2 + b^2 - a^2$ — the misconception here was that they applied the laws of indices when they factorised as they could not identify the appropriate method to use. The participants did not know how to apply factorisation:

- I can see the difference between two squares. I can see that it's a trinomial
  $2^2a^2 + b^2 - a^2$
  $2(a+b-a)(a+b+a)$ (P1: 1).
- I first get the index in the bracket and then I will have a trinomial $2a^2 + b^2 - a^2$ (P2: 5)[13].
- I will make two brackets. In other words $2a + b$ in one bracket and $2a + b$ in the other bracket minus $2a^2$ (P3: 6)[14].
- Do not know what kind of factorising it is. First I got the square in the bracket, then it will be $2^2 \times a^2 + b^2 - a^2$ and then simplify to $4a^2 + b^2 - a^2$. Then you subtract it and you get $3a^2 + b^2$ (P4:7)[15].
- I expanded the bracket and then simplified it to get $3a^2 + 4ab + b^2$ and then took out the common factor (P5: 8).
- What I did $2a + b$ square. Wrote it separately so I did the same with the $-a^2$. Add the like terms together so $4a^2 + 4ab + b^2 - 2a$. Then add similar terms. Final answer $3a^2 + b^2 + 4ab$ (P6: 9).
- When factorise these we simply know that $(2a+b)^2 - 2^2$ we definitely know that $2a + b^2$ is the same as $(2a+b)(2a+b)$ so therefore we say these two terms are the same we are going to eliminate one where we simply going to say the answer is going to be $(2a+b)(1-a^2)$ that will be our answer (P7: 10).

Figure 4.5 illustrates how the misconceptions regarding factorisation (Tables 4.2 and 4.10) had an influence on the respondents' metacognition of how they combined different Mathematics concepts to understand when to apply different methods to solve Mathematics problems (Darling-Hammond et al., 2009b).

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13 Ek gaan eers die eksponent in die hakie kry dan gaan jy 'n drie term het $2a^2 + b^2 - a^2$ (P2: 5).

14 Ek sal eers twee hakies maak. Met ander woorde $2a + b$ in een hakie en $2a + b$ in die ander hakie minus $2a^2$ (P3: 6).

15 Weet nie watter tipe faktorisering dit is nie. Eerstens het ek die kwadraat in die hakie gekry dan sal dit wees $2^2 \times a^2 + b^2 - a^2$. Dan sal ek vereenvoudig na $4a^2 + b^2 - a^2$. Dan trek jy dit af en jy kry $3a^2 + b^2$ (P4:7).

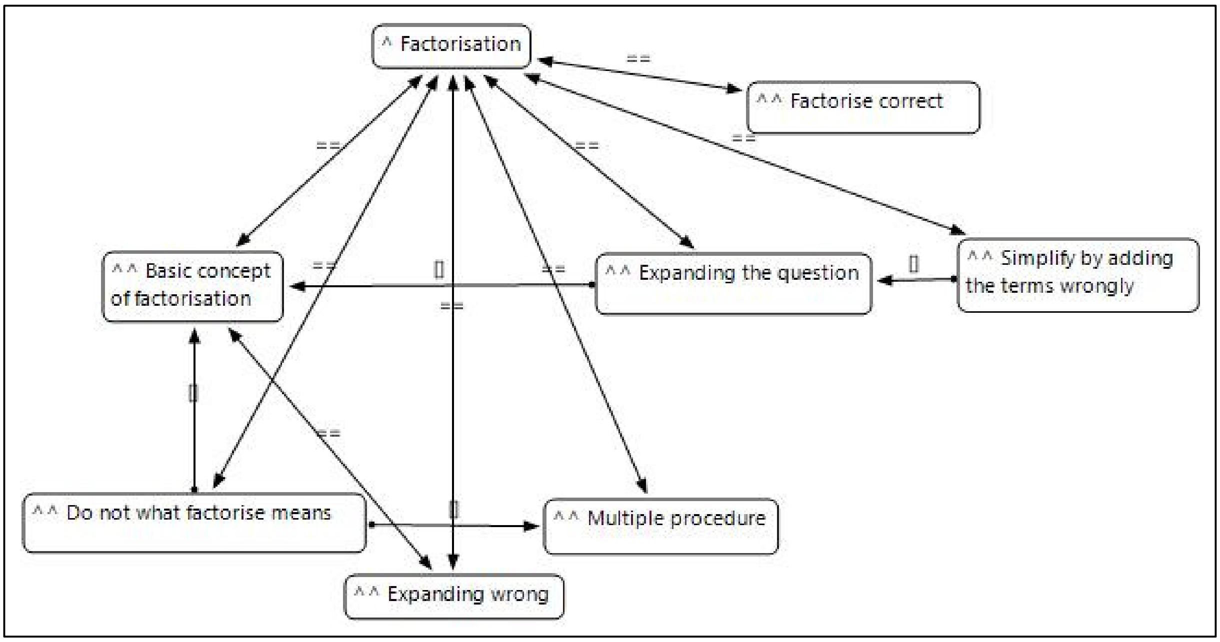

Figure 4.5: Misconceptions of factorisation

4.5 Chapter summary

In summary, Figure 4.2 illustrates the misconception relating to factorisation. The participants did not comprehend the concept of factorisation or that there were different methods of factorisation. Their insufficient pre-knowledge contributed to the problem and they expanded the questions by multiplying the terms with each other, and subsequently added the similar terms correctly. The participants did not know in which situations factorisation could be used in Algebra. Irrespective of the misconceptions made by the students from the diagnostic test, some of these misconceptions showed a lack of conceptual understanding of factorisation, exponents and equations. Often students concentrated more on finding a right answer than on understanding the mathematics theories and questions. Many students see their assignments or questions as getting through a problem rather than working with a concept or theory. Getting the answer is often seen as more essential than understanding. Every misconception made by the student's origin in previous learning. Misconceptions can be seen as the result of student's efforts to build their own knowledge and these misconceptions are intelligent constructed based on incomplete pre-knowledge. Misconception must not be neglected.

Chapter Five

Development, implementation and evaluation of a screencast for N2 Mathematics Education according to phase 1 findings

5.1 Introduction

In order to support students with Mathematics misconceptions, technology such as screencasts can be employed to enrich student learning experiences. This chapter describes the design, development and evaluation of screencasts for N2 Mathematics students at the Kathu Campus. This process relates to phases 2 and 3 of the research procedures. The screencast was developed according to the design principles already established during phase 1. Figure 3.2 indicates that during the evaluation of the screencasts further design principles will be established that will consequently be used.

This chapter is presented according to the identified phases of (i) development of screencasts according to principles identified in phase 1 (§ 5.2); (ii) implementation of the screencasts (§ 5.3); and (iii) evaluation of the screencasts (phase 3, Figure 3.2) in order to ascertain further principles (§ 5.4).

5.2 Developing screencasts according to identified findings

A screencast can be defined as a video that demonstrates what happens on a computer screen (Bamberger & Schultz-Ferrell, 2010). Everything that can be displayed on the computer monitor can be part of the video, for example, conventional explaining of a Mathematics problem by talking and writing by hand. Screencasts can be integrated across the curriculum and into many learning activities. They can assist educators to keep communication simple, and augment text. Screencasts offer students a student-centred and an engaging learning encounter. Screencasts have many applications, which include:

- software training
- teaching of specific content or topic
- selling of merchandise
- blogging and YouTube™ applications
- communication of opinions (Engelhart, 1997).

The screencast should be brief and also be student-centred (not teacher-centred); pedagogically-led instead of technologically-led (Herrington, McKenney, Reeves, & Oliver, 2007). Screencasts provide a number of advantages for students like:

- flexibility for easy retrieval
- screencasts can be stopped, wound back, or repeated multiple times

- students connect better with known technology (Mullamphy et al., 2010).

Students using screencasts claim that screencasts assist in their understanding of Mathematics techniques(Jordan et al., 2012b). Students' confidence increases while learning Mathematics with the aid of screencasts. Students' opinions on why screencasts are important for their learning indicated:

- viewing a problem being resolved and explained by a qualified Mathematician listening to the reason for a specific problematic solving method
- involving willingly with the material offered, thereby remembering it more clearly (Loch, Jordan, Lowe, & Mestel, 2013).

The development of screencasts for this project entailed various steps. The developmental steps related to (i) planning and preparation; (ii) recording; (iii) editing; and (iv) distributing.

5.2.1 Step 1: Planning and preparation

It is important to prepare well before the recording of screencasts in order to diminish unnecessary editing of the final product. Collect all the content to be included in the screencasts. The voiceovers should be rehearsed beforehand in order to determine where the voice artist should break for breath, place emphasis on certain areas, or provide time for the user to grasp the content. Compile a full audio script for the full screencast, and practise reading it out aloud. Refrain from using long sentences and practise difficult words and tongue twisters, or substitute them for simpler ones. Keep the screencast short, about five to ten minutes. Only one goal or concept should be addressed during a screencast. Create a series of screencasts when the topic is complex. Provide concrete examples during the application of theory (Burkhardt, 2006).

During the use of the four findings (Figure 3.2), three central misconceptions were identified relating to Mathematics concepts (Table 4.3, § 4.3): (i) index laws, (ii) equations, and (iii) factorisation. These misconceptions formed the principles for the development of the TEL application: (i) to improve the students' understanding of Mathematics concepts, and (ii) to apply different strategies to solve Mathematics problems. During the planning of the screencast, the following strategies guided the technological development of the screencast video:

1. Formulating the purpose of the screencast in order to stay on task
2. Identifying examples to be used as example content for the video. They related to:
    (i) index laws
    (ii) equations
    (iii) factorisation
3. Unpacking the examples in order to ascertain that they address the required content and logical flow of explanation
4. Compiling a detailed storyboard for the development of the screencast.

5.2.2 Step 2: Recording

Speak slowly and clearly while following the script closely. Talk naturally and be yourself; keep a specific person in mind while unpacking a topic. Do not rush to meet the five-minute limit—rather split the content into more than one screencast. Failing to do this only means that the students will have a harder time to understand the content. Close all unnecessary programs on the computer before you start recording as screencasting programs are resource-hungry and slow down your computer. Find a quiet place to do the recording and use a good microphone for good sound quality (Burkhardt, 2006).

The screencasting program used during this study was Camtasia Studio 7.

5.2.3 Step 3: Editing

Editing of screencasts relate to graphics, special effects, music and audio. Avoid unnecessary editing. In addition to wasting time, unnecessary editing can interfere with the quality of the sound. Repeat the recording process when the quality of the screencast is not satisfactory (Burkhardt, 2006; Herrington et al., 2007).

5.2.4 Step 4: Distributing

Most screencasting programs have an automatic export function that ensures high quality of the applications. The screencasts can be published in a variety of formats, including CDs/DVDs, mobile applications like phones, tablets, iPods and iPads, computer-based applications, Internet-based applications (Bamberger & Schultz-Ferrell, 2010; Herrington et al., 2007). During this study the screencasts were copied to DVDs as the demographic information (Table 4.1) indicated that it was the technology most prevalently available to the students.

The screencast the researcher prepared for Mathematics N2 on laws of indices misconceptions is available as Addendum 5.1. Figure 5.1 provides a screenshot of the screencast relating to misconception 1 (index laws).

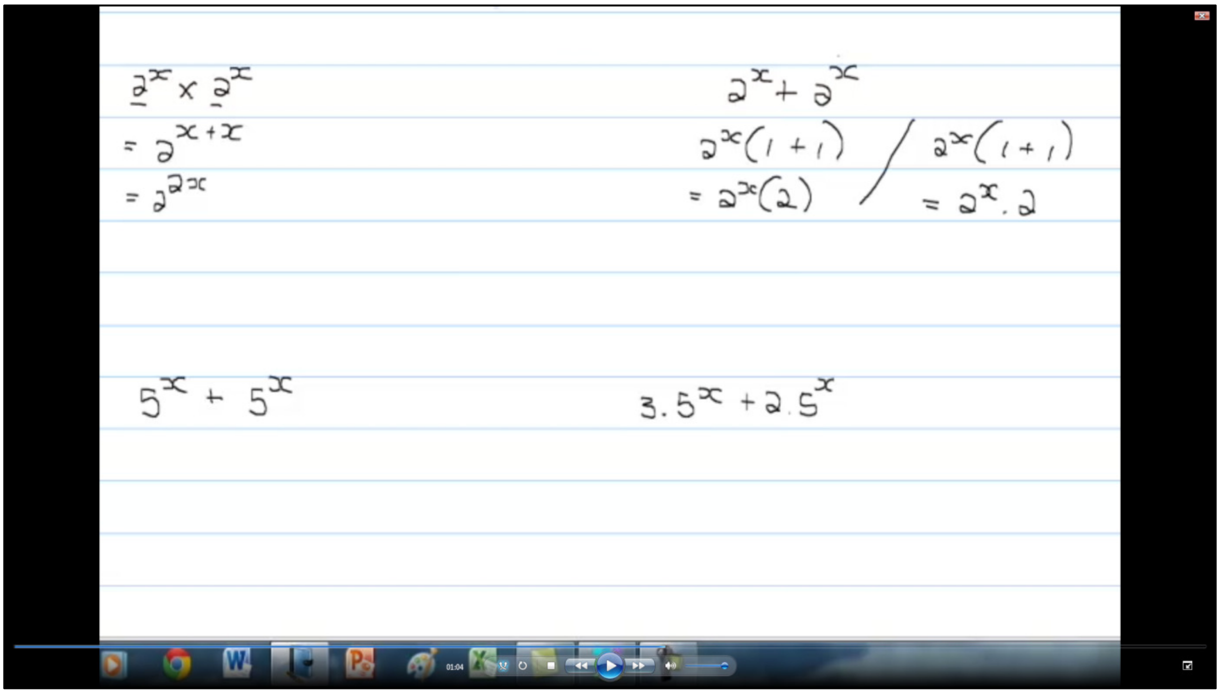

Figure 5.1: Interface of the screencast relating to misconception 1 (index laws)

5.3 Implementation of the screencasts

The researcher implemented the screencasts during the second trimester of 2013 with the N2 Mathematics students. The screencast was made available to these students, not only for the interview participants, but to all those taking part in the research. Using the screencasts was optional to the students as receiving the DVD was voluntarily. A few students did not immediately accept a DVD and most returned a few days later and collected it. After viewing the DVDs some students requested that screencasts should be made available to all problem areas of N2 Mathematics, not only the areas identified in this research.

5.4 Evaluation of the screencasts as part of iterative student feedback

The evaluation of the value of the screencasts was performed as a quantitative survey with 23 respondents (Addendum 5.2, questionnaire and Addendum 5.3; frequencies and percentages). It was optional for the students to complete the questionnaire. The questionnaire, comprising nine open- and closed-ended questions, prompted the participants on the value of screencasts in order to assist them to better understand the misconceptions they experienced. Table 5.1 represents the quantitative data of the questionnaire.

Table 5.1 Quantitative questions and data relating to the evaluation questionnaire on screencasts

Questions	Options	Counts	Percentage
1. Q1 Have you viewed the screencasts provided to you on the DVD?	Yes	19	83
	No	4	17
2. Are screencasts easier to understand than the text book?	Yes	21	91
	No	2	9
3. Do you want the screencast done in typing or handwriting	Hand writing	18	78
	Typing	4	17
4. How many times did you use the screencast?	0 times	2	9
	1-2 times	10	43
	3-4 times	8	35
	More than 5 times	2	9
5. For what purpose did you use the screen cast?	Revision	10	43
	Clarity	11	48
6. How favourable or unfavourable is your opinion of the videos?	Poor	0	0
	Fair	1	4
	Good	7	30
	Very good	7	30
	Excellent	6	26
7. How useful do you find the videos?	Not at all useful	0	0
	Somewhat useful	1	4
	Neutral	0	0
	Useful	9	39
	Very useful	11	48
8. What things do you like most about the videos? (up to 3 responses)	Personalised	6	26
	Demonstration	12	52
	Time	1	4
	Repeat	16	70
	See lecturer	9	39
	Hear lecturer	9	39
	Do not know	0	0
	Other	0	0
9. What things do you like least about the videos? (up to 3 responses)	Too short	6	26
	Difficult	1	4
	Errors	1	4
	Time	0	0
	Do not know	6	26
	Other	4	17

Question 2 prompted the respondents if screencasts were easier to understand than the textbook. Twenty six respondents were of the opinion that the screencasts contributed towards their understanding of the course material:

- The explanation is easier to understand, because there are more steps
- The ability to see what the lecturer is doing, makes the work easier
- Because it is like I am in a classroom unlike doing on my own.

The majority (78%) of the respondents liked the handwriting in the screencasts. Half of the respondents who responded to the question watched the screencast more than twice and the other half more than three times. They used screencasts almost equally for revision for tests and examinations (43%), or to get more clarity (48%). Most of the respondents (48%) found the screencast very useful and 39% found it useful. One participant indicated that the screencast was somewhat useful. They liked the fact that they were able to watch it more than once, as well as the demonstration of how to find what they needed. Question 10 of the questionnaire prompted the participants on recommendations to improve the screencast:

- Give more and explain more expressions
- To save it in different types of format so one will be able to watch it on a DVD at home if you do not have a computer
- I think it will be good to give it to the students just when starting with classes so that lessons in class become improvement of what they've already seen
- Explain more clearly and to make the sound more pure
- Need more examples, mostly the typical exam question
- Screencast for all the subjects. They are very handy
- It should be done permanently
- Try not to be fast when demonstrating, I am a slow learner. But I think they must be used in all subjects.

5.5 Challenges

Not all students had access to computers or tablets to download screencasts. Therefore only some students would benefit from the additional support. It became evident that the application could not meet all participants' personalised needs. They also cannot ask a question when they do not understand. Some participants wanted screencast for all subjects, but not all lecturers are willing to take all the additional trouble of compiling screencasts.

New principles emanated from the evaluation of the screencast:

- the participants used screencasts as a scaffolding tool in steps for lifelong learning, therefore improving their metacognitive skills
- they learned that Mathematics questions could be broken down into small steps (building blocks)
- the screencasts motivated the participants during their Mathematics learning
- the screencast contributed towards their metacognition of Mathematics principles
- the students changed their attitudes towards Mathematics, as well as towards taking part in learning activities during classes
- support flexible and personalised learning
- supplement lectures and can enhance understanding of key concepts
- offer multi-modal support for studying and difficult concepts

5.7 Chapter summary

Screencast have emerged as an outstanding teaching instrument on the Internet. Screencasts are an efficient method to communicate concepts, deliver subject knowledge, and obtain students' comments. Screencasts can be used across all classes. To make educational screencasts that meet content aims requires careful preparation with detail and focus. It seems that screencasts could be an influential, efficient and cost-effective learning tool that could facilitate learning across all curricula. Screencasts can therefore be seen as making subject knowledge available for students at all times, expanding student-teacher communication, and collaboration, concentrating and aiming on mastery of subject knowledge and letting students study and do revision at their own pace. Screencasts can be an influential instrument to support education and learning.

Chapter six

Synthesis, conclusion and reflections on the use of a case study for developing a technology tool for N2 Mathematics

6.1 Introduction

Students perceive Mathematics as one of the most demanding subjects. Owing to their inadequate high school Mathematics foundation, many students are nervous about and intimidated by Mathematics when returning to colleges some years after they have completed their schooling. This research relates to what the misconceptions of such students in Mathematics were, how they were established, and how the use of a TEL tool like screencasting could address misconceptions for learners in order to increase their metacognition of Mathematics concepts to solve problems.

This chapter addresses the research questions, makes recommendations for further research, points out the limitations of the research, describes the value of the research, and reflects the personal research journey of the researcher with case study as selected methodology.

6.2 Summary of chapters relating to the research journey

The study is presented as six chapters; each with a definite focus and explicit outcome. The following sections provide a synopsis of each of the chapters with aim to contribute towards addressing the research questions (§ 1.3).

6.1.1 Chapter One: Orientation to the use of screencasts in an N2 Mathematics course

Chapter One provided an overview of the study in order to orientate the reader in terms of the structure of the research report, the context of the study, the literature that underpinned the study, the purpose of the study, as well as the research questions the study aimed to address.

Chapter One familiarised the reader with the value of Mathematics in the technical field of engineering. The students participating in the study as research participants intended to become artisans. They adhered to the minimum requirements of the qualification by passing four subjects, of which Mathematics was compulsory, and it prevented them from commencing with the practical aspects of becoming an artisan if they had not passed all four subjects. Mathematics is more often than not the subject which prevents students from attaining their certificate. Many students have a negative attitude towards Mathematics and they believe that school Mathematics comprises prescribed procedures that are far removed from their everyday lives. Students do not arrive at the FET College *tabula rasa*—as clean slates or pages. They enter the FET teaching space with many misconceptions that have the potential to derail their learning. Students' misconceptions also have an effect on classroom-based teaching and learning. Educators should identify and eliminate misconceptions in order to develop students' metacognition of Mathematics concepts.

Chapter One also provided a brief overview of case study as the research methodology to be used during the study, the context of the study, the sampling procedures and the target population.

6.1.2 Chapter Two: Reviewing of literature

Educators at all levels of education, especially at the lower secondary school levels, should recognise and examine students' Mathematics misconceptions. Various researchers have identified methods to recognise, prevent, and correct Mathematics misconceptions (Alkhalifa, 2006; An & Wu, 2011; Bamberger & Schultz-Ferrell, 2010; Craighead, 2012a). Students in blended settings have an advantage over students who learn through traditional instructional approaches when it comes to utilising information to understand better and solve problems effectively. Furthermore, students learning in blended education settings experience better metacognition that assists them during analysis, problem-solving, and self-learning (Lovett, 2008; Yoong, 2002). A well-organised environment that offers a selection of hands-on and minds-on experiences is critical to the effective implementation of a blended learning strategy (Hmelo-Silver, Duncan, & Chinn, 2007). In order to assist students to become satisfied students, the use of screencasts as a TEL tool has potential to enhance learning experiences required for metacognition and deep learning of Mathematics concepts. Not only can the use of screencasts address some profound misconceptions, they can also be personalised with direct benefits for individual students. In addition, screencasts could provide scaffolding of foundation knowledge in order to attain new knowledge (McLoughlin & Lee, 2008). Not all students will have the same interests and expertise and abilities to study Mathematics. Some students will find it pleasant; others will find it stimulating, some will find the theorems and different outcomes fascinating, others will find the formulae and rules confusing and puzzling. It is therefore important for the Mathematics educators to differentiate in Mathematics steps and use different pathways and choices to encourage every student in order to make the most of his/her Mathematics potential. The educator must take cognisance of the 21st century student, who is digitally relaxed with the use of technologies and who works and thinks differently. The learning of Mathematics must take cognisance of the new age group of students, the inventions in pedagogies as well as the affordances of technologies.

6.1.3 Chapter Three: Case study research design and methodology

This study used case study as part of the research design and methodology. It uncovered N2 students' misconceptions in Algebra. This study is particularly appropriate for a case study design as it is a bounded system. Bounded cases are distinctive studies in terms of time era, place, physical limits, social groups, organisations or geographical region, according to Creswell (2009). The main research strategy was the use of a customised diagnostic test, accompanied by a biographical questionnaire in order to collect quantitative data, while interviews accompanied by a set of problems comprised the qualitative phase. Students' responses to the diagnostic test and their interview transcriptions were concurrently used as multiple data sources to reach evidence about students' misconceptions. The participants completed a questionnaire regarding the value of the screencasts and they shared their perceptions and experiences about the screencasting videos that the researcher compiled.

A case study is a realistic study that examines a current uniqueness comprehensively and within its realistic environment, predominantly when the restrictions between distinctiveness and situation are not perceptibly noticeable. The case study investigation deals with the hypothetically distinctive circumstances in which there will be several variables of significance. As one conclusion hinges on several resources of validation, data are required to assemble in a triangulating method. Another significant benefit is the development of hypothetical proposals to influence data collecting and inspection (Yin, 2009). Maree (2007) states that case study research is a qualitative technique in which the researcher examines a bounded arrangement (case) or multiple bounded arrangements (cases) over time, through wide-ranging, comprehensive data collection, including numerous sources of data, and reports a case description and case-based themes.

6.1.4 Chapter Four: Phase 1 analyses of integrated data of a Mathematics education

Misconceptions hamper students from attaining Mathematics outcomes. Learning becomes more useful and efficient when common misconceptions are systematically uncovered and resolved (Allen, 2007; Swan, 2000). Allen (2007) proposes that when students confront a challenge to their cognitive structure, they are much more eager to apply themselves effectively. Metacognition increases and the student advances from the current theme to broader situations. He reasons that without uncovering students' misconceptions, they may not know why a misconception was established. Mathematics interventions should use thoughtful procedures to uncover faulty thinking and allow students to challenge their own misconceptions (Wiig & Wiig, 1999).

This chapter relates to the analysis of the three collected datasets of quantitative and qualitative methodologies. The research instruments used in the different phases of the research were identified and comprised: (i) an open-ended question, asking the students' demographical information (ii) a customised diagnostic test of twelve questions in which students had to demonstrate all the steps of their thinking, and (iii) interviews with identified students because they demonstrated the most misconceptions during the diagnostic test. The most common misconceptions were identified, and the use of principles relating to index laws, equations and factorisation were implemented.

(i) Index laws

Knowledge of powers, or indices, is important for an understanding of most Algebraic procedures and methods. Indices are important in simplifying expressions involving indices, using negative and fractions indices. Misconception in indices is due to weaknesses in working with fractions and negative numbers. Indices demonstrate the repeated multiplication of a number or variable by itself. Common misconceptions are:

- Multiplying base and index: $2^3 \neq 2 \times 3$.
- A negative exponent and a negative term are not equal $-3^2 \neq 3^{-2}$.
- Students add when they are supposed to multiply; they do not realise how to apply index laws correctly.

(ii) Factorisation

A common misconception is trying to "cancel" before factorising, or when asked to simplify, students multiply out the factors:

$$\frac{2y^2+4y}{y^2+3y+2} = \frac{\cancel{2}\cancel{y}^2+4y}{\cancel{y}^2+3y+\cancel{2}} = \frac{4\cancel{y}}{3\cancel{y}} = \frac{4}{3} \text{ or } \frac{x+2}{(x+3)(x+2)} = \frac{\cancel{x}+\cancel{2}}{(x+3)(\cancel{x}+\cancel{2})} = \frac{0}{3} or 3$$

Students show a combination of misconceptions during factorisation problems. Students misinterpret factorisation as though it were not logical to them. Students do not understand the concept of factorisation. Factorisation is part of many basic Mathematics manipulations, like solving a variable, functions, limits, differentials and trigonometry. While expanding is predictable, factoring can be complicated, and students will need a lot of exercise and repetition to master different kinds of factorisation that arise, as well as gain understanding into what procedures to apply and ability in applying the laws and rules correctly. Therefore factorisation must be seen as a method by which a student attempts to make a mathematical expression look like a multiplication problem by considering different factors.

(iii) Equations

Students generally do not know where to start with solving equations. The students tend not to identify the different types of equations correctly, for example exponential equations or quadratic equations. The students struggle with parentheses or distributive properties, and also with equations that have more than one answer. The zero products are a challenge and many students become confused when the answer is zero. Mathematics seems to get more difficult and complex when the student starts doing equations and applying symbols like x and y as a replacement for numbers.

Most of the misconceptions shown in this case study should have been mastered long before a student arrived at the college. The concepts and basics of Mathematics should be taught effectively at lower levels. When students have misconceptions, it may be due to insufficient understanding of which approaches or methods to use and how these approaches must be applied. The student does not realise that Mathematics is not about answers, but about the steps in the journey to arrive at the answer.

6.1.5 Chapter Five: Development, implementation and evaluation of a screencast for N2 Mathematics Education according to phase 1 findings

Screencasts have been developed as an excellent instruction tool on the Internet. Screencasts are efficient when communicating concepts and delivering content. To create educational screencasts that meet content aims, requires careful preparation, with detail and focus. This study has determined that students like short, to the point Mathematics screencasts. Screencasts accommodate for on-the-go and self-directed students who prefer to learn by seeing and hearing. Students were of the opinion that the screencasts contributed towards their understanding of mathematical procedures, methods and concepts. They requested that other subjects also make use of screencasts as part of content support. Screencast can be seen as an-educator-on-demand. Screencasts allow students to study by example, see step-by-step sequences of a Mathematics question or problem in much detail, or observing a screencast directly connected to an example or problem. Therefore screencast can be seen as a helpful way to distribute information on certain topics or content.

6.2 Addressing the research questions relating to this design-based research study

6.2.1 Research question 1: What are the N2 students' misconceptions relating to Algebra?

When studying the occurrence of the Mathematics misconceptions revealed during the application of diagnostic tests, it is important to remember that most students passed grade 12 Mathematics and Natural Science or the N1 qualification. The biggest misconceptions relating to the application of index laws were.

(i) Question 4 of the diagnostic test was: Simplify $2^x + 2^x$. Either 2.2^x or 2^{x+1} was accepted as the correct answer. The most common answers were 4^x, 2^{x^2}, 2^{2x}, and 4^{2x}.

(ii) The second misconception was solving for $x : \frac{1}{x} - \frac{1}{a} = \frac{1}{b}$. The most common answer was $x = a + b$. Students grappled with using a common denominator. They tried to separate rules or methods that they did not understand adequately. Student did not know how to deal with the question, or how to classify the problem. Some answers were $\frac{ba - xa - xb}{xba} = x$;

$ab - ax - xb = 0$ and $\frac{ab - ax - xb}{x - b - a} = 0$.

(iii) The third misconception was the factorisation of the difference between two squares. The most common answer was $3x^2 + 4xy + y^2$. The students did not recognise the problem as factorisation and some tried to expand, and simplify the problem. Some of the other answers were: $x^2 + y^2$; $3x^2 + y^2$ $((2x+y)-x)((2x+y)+x)$. Questions 6, 7, 8, and 9 required factorisation, which seemed a big problem (Table 4.2). An example of answering question 6 was:

$$x^2 = 81$$
$$x = 40{,}5$$
$$= 81$$

Four students answered question 7 as follows:

$$x^2 = 4x$$
$$x = \sqrt{4x} \quad \text{or} \quad \begin{matrix} x \neq 0 \\ x = 4 \end{matrix}$$
$$x = 2x$$

For question 8, students incorrectly gave the answer as $x^3 - 4x^2 + 3x = 0$ (Addendum 4.2). In question 9, twelve students provided $x = 1$ as the answer. It seemed that factorisation was a major problem to the students. If the students had had the necessary metacognitive skills, they would have correctly identified the question and subsequently applied factorisation. They did not recognise the type of factorisation the problems related to, or use the correct method of solving the problem. Students should read the questions meticulously, understand what they have read, analyse the question and write down what was given, explore all options to solve the question, plan which options would be best suited, implement their plan, verify and test the answer (South Africa, 1996). The students should know the different kinds of factorisation, and when to use which method.

6.3.2 Research question 2: To what extent could students' misconceptions be addressed by using screencasts in order to increase their metacognition of Mathematics concepts?

Most research participants who viewed the screencasts preferred learning with the screencasts because they were of the opinion that it made the understanding of the text book easier. They liked it that they could repeat the lesson over and over and almost half of the participants (43%) viewed the screencast three to four times. Most participants liked to see the demonstrations in the educators own handwriting and hear the educator's voice. Personalisation was important to them. They asked that other subjects should also include screencasts, and requested more Mathematics examples. The research participants made recommendations for the design and development of screencasts: "Try not to be fast when demonstrating, I am a slow learner." One could deduce that using screencasts to promote metacognitive strategies solved misconceptions during support of students with difficulties in learning. The screencasts showed students how to break down the questions, and step-by-step supported them to enhance their metacognition of Mathematics concepts. Supporting the student with problems and teaching the students scaffolding is important.

6.4 Recommendations

The uncovering of findings played a role in the understanding of the purpose and development of the research. The findings guided the steps towards the next phase of the research. This study indicated that the findings from phase 1 relating to Mathematics concepts which regularly led to students' misconceptions related to were: index laws, equations, and factorisation. The researcher proposes that other researchers and further studies confirm these findings from a contained case study in order to further validate the findings.

During phase 4 further findings emanated from the evaluation of the screencast that related to (i) the viability of using screencasts as scaffolding tool in steps for lifelong learning and network theory, (ii) the advantages of Mathematics problems broken down into small steps; (iii) the motivational aspects of the screencasts to enhance the learning outcome of Mathematics students, (iv) the contribution of screencast towards metacognition of Mathematics concepts; and (v) the change of Mathematics students' attitudes, as well as their increased participation in learning activities during classes. Metacognition was about taking ownership of their learning and take full advantage of it. The screencast helps the students to form and shape their personal scaffolding. The purpose of the screencast was not to teach how to factorise or solve variables, but also to reflect on their own studying and learn different methods to solve problems. Metacognitive regulation occurs when the students made use of the metacognitive skills to direct their data and thinking in answering and explaining problems. The researcher proposes that other researcher and further studies confirm these findings from a contained case study in order to further validate the findings.

6.5 Further research

There were a number of additional questions that emanated during the research:

- How do screencasts contribute towards the outcomes of N2 Mathematics?
- How could the findings from this first cycle bounded case study be used for other subjects at the FET College?
- How could the screencasts be improved to meet educational and instructional design principles?
- How could other lecturers be co-opted in the use of screencasts?

6.6 The value of the research

The screencasts contributed towards the students' improving enthusiasm, self-efficiency, and their attitudes of learning Mathematics with technology. The real value for the student lies in his/her passing the subject. This aspect should still be researched. Research on misconceptions has not been performed previously at a FET College in South Africa before. Similar research has previously been performed at school level in South Africa. This study illustrated the use of a research instrument to establish new teaching approaches to address students' misconceptions.

Screencast are examples of TEL and instructional structures through which students obtain support, usually with the help of educators, support instruments, and technical resources (Wang & Hannafin, 2005a). The use of such systems could assist students who were absent during classes and the students who do not resolve their problems in class as they do no ask questions. TEL has an important role to play in addressing the misconceptions of all subjects. An advantage of using TEL is that it can influence lecturers to start their teaching *where the student is at* and to work from there. TEL permits the use of tools that allow for separate exercises, responding to the objectives of students' needs with powerful and important features of Mathematics, that relate to the lives of students in their actual worlds.

6.7 Limitations of the study

Criticism against case study methodology is that its frequency is always levelled against the dependence on one case and therefore it is claimed that case study research is incapable of providing generalising conclusions (Creswell, 2009; Fraenkel et al., 2012). Researchers' preparation might not be adequate when using mixed method research. Characteristically the research necessitates more extensive data collection, time and resources. Mixed method researchers also find it challenging to write reports and establish deductions (McMillan & Schumacher, 2014).

The researcher experienced the interviews as challenging and not the best solution to collecting data. The main pitfall was that the participants were not comfortable participating in the interviews. Time constraints prohibited the researcher from performing the research over a longer period of time in order to attain more data and further ensure the reliability of the data. Although the study indicated that the screencasts contributed towards positive learning experiences and student motivation, the study could not confirm that screencasts made a difference to the students' achieving learning outcomes. During further research this goal could be addressed.

The research site was about 900 kilometres away from the NWU and the Internet connectivity in the rural areas of the Northern Cape is erratic and slow. In order to download an article, one has to find a suitable spot to connect to the Internet. Even mobile phones are not always trustworthy. Study leaders and library resources were also at a distance.

6.8 Reflection on my personal research journey

This study changed the way I think about teaching Mathematics and the way I plan my Mathematics lessons. I now constantly think about Mathematics misconceptions; where to start; how to address them; what questions to ask; how to explain the theory relating to the misconceptions; what led to the misconception; and how to build on pre-existing knowledge the students bring to class. I listen more carefully when students ask a question. I embarked on using rich collaborative tasks and make more extensive use of technology in order to motivate students and make them more enthusiastic about classes. I learned much about Mathematics education, as well as how to manage my Mathematics resources. This research has been a mind-changing and a worthwhile experience for me as I enjoyed the fun of planning, preparing, recording of the screencasts, and the students' reactions to something novel. The words of a participant linger in my head: "Mathematics is not that difficult."

Doing the research and writing the report was not without incidents. After the resignation of my initial study leader and the cancellation of the research project that this study adhered to, uncertainty clouded the progress of the research report. It was, however, with gratitude that I accepted the newly appointed study leader who encouraged and guided me to complete my research journey to the very end.

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TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 1			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$\frac{50}{49}/1\frac{1}{49}/1{,}02/1\frac{2}{98}$
1	$1\frac{1}{49}$	10	7	17	
2	$\frac{50}{49}$	24	23	47	
3	$1\frac{2}{98}$	3	1	4	
4	$1{,}020$	7	3	10	
5	$1\frac{1}{50}$	1		1	
6	Didn't answer	1	3	4	
7	2	1	1	2	
8	$\frac{100}{98}$	2		2	
9	$\frac{5^2}{7^2}$	1		1	
10	$\frac{25}{24}$	2		2	
11	$\frac{2\times 5^2}{7^2}$		10	10	
12	$=\frac{50}{7^2}$		1	1	
13	$10^2/2*7^2$ -4		1	1	
14	$=\frac{25}{36}$		1	1	
15	$2.5^{.2}.7^2$ 2		1	1	
16	$\frac{10^2}{2\times 7^2}$		1	1	
17	$2.5^{.2}.7^2$ 2450		1	1	
18	$\frac{\sqrt{10}}{\sqrt[7]{2}}$		1	1	
19	Rewrote question		1	1	
20	$\frac{10^2}{7^2}$		1	1	

21	$\frac{\log 100}{\log 98}$ $= \frac{2}{1,99}$		1	1	
22	$1\frac{2}{98}$ $\frac{1}{49}$		1	1	
23	$2.5^{-2}.7^{2}$		1	1	
24	$\frac{2\times 5^{2}}{7^{2}}$ $\frac{5^{2}}{2^{2}}$		1	1	
TOTAAL		52	61	113	

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TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 2			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$8/2^3$
1	8	41	22	63	
2	$\frac{1}{8}$	4		4	
3	$\frac{1}{2}$	2		2	
4	$\frac{1}{\frac{1}{8}}$	1	1	2	
5	1	1		1	
6	$\frac{1}{16}$	1		1	
7	$\left(\frac{1}{2}\right)^9$	1		1	
8	2^{-3}	1		1	
9	2^3		11	11	
10	$\frac{2^3}{1\frac{3}{\,}}$		4	4	
11	$\frac{2}{1}$		1	1	
12	$\frac{8}{1^3}$		1	1	
13	$\left(\frac{-3}{-6}\right)$ $=\frac{1}{6^3}$ $=216$		1	1	
14	$\frac{1^{-3}}{2^{-3}}$		4	4	
15	Didn't answer		1	1	
16	$\frac{1^{-3}}{2^{-3}}$ $\frac{1^{\frac{1}{3}}}{2}$		1	1	
17	2		2	2	
18	$-\frac{3}{2}$		2	2	

TRIMESTER 1&2: PHASE 1&2

19	$\frac{2^3}{1^3}$ $\frac{8}{3}$		1	1	
20	$\left(\frac{1}{2}\right)^{\frac{1}{3}}$ $=6$		1	1	
21	$\left(\frac{1}{2}\right)^{-2}$ $\frac{1}{2}+\frac{2}{0}$ $\frac{3}{2}$ $1{,}5$		1	1	
22	$\frac{1^{-3}}{2}$ $\frac{1}{\frac{1^{3}}{2}}$		1	1	
23	$\frac{1^{-3}}{2^{-3}}$ $\frac{1}{1^3 2^3}$		1	1	
24	$\frac{2^3}{3}$		1	1	
25	-8		1	1	
26	$\frac{1^{-3}}{2^{-3}}$ $1^{-3-1}.2^{-3+3}$ $\frac{1^{-4}}{2^0}$ $\frac{1}{1^4}$		1	1	
27	Rewrite answer		1	1	
28	$\frac{2}{3}$		1	1	
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 3			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$3^{2x}/9^{x}$
1	3^{x+x}	1	1	2	
2	3^{2x} 9^{x}	1		1	
3	3^{2x}	42	48	90	
4	9^{x^2}	1	2	3	
5	$x=\frac{1}{2}$	1		1	
6	3^{x^2}	1		1	
7	$2x$	1		1	
8	3^{4x}	1		1	
9	9^{2x}	3	3	6	
10	9^{xx}		1	1	
11	6^{x^2}		1	1	
12	9^{x^2} 3^2+x^2		1	1	
13	Rewrote question		2	2	
14	3^{x-x} 3^0 1		1	1	
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 4			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconceptions	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$2.2^x / 2^{x+1}$
1	4^x	19	21	40	$= 40/113*100$ 35.4%
2	$2^x + 2^x$	7	9	16	
3	4^{x^2}	1	3	4	3.5
4	2^{x^2}	14	5	19	16.8
5	x^2	1		1	
6	2^{x+1}	1	2	3	
7	2^{4x}	1	1	2	
8	1	1		1	
9	4^{2x}	3	8	11	
10	2^{2x}	4	10	14	
11	2^x		1	1	
12	$4x^2$		1	1	
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 5			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		a^{b+c}
1	a^{b+c}	38	41	79	
2	a^{bc}	11	16	27	
3	$2a^{bc}$	1		1	
4	bc	1		1	
5	$b+c$	1		1	
6	Didn't answer		1	1	
7	a^{2bc}		2	2	
8	Rewrote question		1	1	
TOTAAL		52	61	113	

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TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 6			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$x = \pm 9$
1	$x = 9$	50	35	85	
2	$x = \pm 9$	2	14	16	
3	$x = 3$		1	1	
4	$9^2 = 81$		1	1	
5	$x^2 = 3^4$ $x = \frac{6}{4}$		1	1	
6	$x^2 = 3^4$ $x = 3$		1	1	
7	$x^2 = 81$ $x = 40,5$ $= 81$		2	2	
8	Didn't answer		1	1	
9	$x^2 = 3^4$ $x = \frac{3^4}{x}$		1	1	
10	$\frac{x^2}{x} = \frac{81}{x}$ $x = \frac{81}{x}$		1	1	
11	$x^2 = 9^2$		1	1	
12	$x = \sqrt{3^4}$		1	1	
13	$x^2 - 81 = 0$ $x^2 = 81$		1	1	
14					
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 7			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$x=0$ $x=4$
1	$x=0$ $x=4$	36	18	54	
2	$x=-2$ $x=2$	5	10	15	
3	$-x=0$ $3x=0$	1		1	
4	$x=4$ Forgot $x=0$	1	2	3	
5	$x=4$	2	10	12	
6	$x\neq 0$ $x=4$	2		2	
7	$(x-2x)(x+2)$	2		2	
8	$x=\sqrt{4x}$	1	1	2	
9	$x=0$	1	2	3	
10	$\frac{x}{-2}=x$ $\frac{x}{2}=x$	1	1	2	
11	$x=2$ $x=+2$				
12	$x=\frac{x^2}{4}$		1	1	
13	Didn't answer		1	1	
14	$2x^2-4x=0$		1	1	
15	$x^2=4x$ $x=\sqrt{4x}$ $x=2x$		4	4	
16	$x^2=2^2x$ $x(x-2^2)=0$		1	1	
17	2^2x-4x		1	1	
18	Rewrite question		1	1	
19	$x^2=4x$ $x=\sqrt{4x}$ $x=2x^{\frac{1}{2}}$		2	2	
20	$\frac{x^2}{x}-\frac{4x}{x}-0=x$		1	1	

21	$x^2 = 4x$ $x = 4x$ $x = 2^2 x$ $x = \frac{1}{2}$		1	1	
22	$(x-2x)(x+2x)=0$ $= x = 2x$ $x = -2$		1	1	
23	$-4x = -x^2$ $x = \frac{-x^2}{4}$		1	1	
24	$x^2 - 2^2 x = 0$ $x - 2x = 0$ $-1x = 0$ $x = 1$		1	1	
25					
26					
27					
28					
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 8			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$x=1$ $x=3$ $x=0$
1	$x=1$ $x=3$ $x=0$	32	15	47	
2	$x=1$ $x=3$ $x\neq 0$	2			
3	$x=\sqrt{3x}$ $x=1$	1			
4	$x=1$ $x=3$ *forgot* $x=0$	1	2	3	
5	$x=-1$ $x=3$ *forgot* $x=0$	4			
6	$x(x^2-4x-3)$	1			
7	$x=1$	1			
8	$x=0$ $x=4$	2			
9	$x=1$ $x=3$ *cancel* $x=0$	1			
10	$(x-1)$ $(x+3)$ $(x-1)$	1			
11	$x=\sqrt{\frac{1}{2}}$	1			
12	$x=4{,}236$ $x=-0{,}236$	1			
13	$x=\frac{1}{2}$	1			
14	$x(1-3)=0$	1			

15	$x=1$ $x=3$ $x=-1$	1			
16	$(x-1)x(x-3=0)$	1			
17	$x^3-4x^2+3x=0$		8		
18	$x=1$ $x=-2$		1		
19	$x=\sqrt{x}$		1		
20	$x=\frac{x^2}{3}$ $x=1$		1		
21	Didn't answer		2		
22	x^3-3x^2-1x+3 x^3-4x+3 $(2x-1)(x+4)$		1		
23	$x(x^2-4x+3)=0$ $\frac{x}{x}(x^2-4x+3)=\frac{0}{x}$ $(x-1)(x-3)=0$ $x=3$ $x=1$		1		
24	$x+x=x=1+2=3$ $=x-x=0=3-=0$		1		
25	Expand and simplify Wrong simplifying $x=0$		1		
26	$x=1$		5		
27	$x^3-3x^2-x^2+3x=0$ $x^3-2x^2+3x=0$ $x=x-2x+3$		1		
28	$x^3-3x^2-x^2+3x$ $=x-x^2$ $x=\sqrt{x}$ $x=x^{\frac{1}{2}}$		1		
29	Used quadratic formule After simplifying wrong No answer		1		

30	$-x^5-6x^3=0$ $-x^5=6x^3$ $-x^2=6$ $x^2=6$ $x^2=2\times3$		1		
31	$x^3-4x^2+3x=0$ $x(x^2-4x+3)=0$ $(x-1)(x-3)=0$		3		
32	x^3-5+4x x^2-9x		1		
33	$x^3-2x^2+x^3-2x^2$ $-1x^5--1x^5$ x^0		1		
34	$(x^3-3x^2)(-x^2+3x)=0$ $(x^2-3x^2)=(-x^2+3x)$ $\frac{(2x)}{2x}=\frac{-2x}{x}$		1		
35	$x^3-4x^2+3x=0$ $(x+1)$ Is a factor $x^2=5$ $x=\pm\sqrt{5}$		1		
36	$x=0$ $x=3$ $x=-1$		1		
37	$x^3-3x-x^2+3x=0$ $x^3-x^2=0$ $x=0/x=1twice$		1		
38	$x^3-3x^2-x^2+3x=0$ $x^2-2x^2+3x=0$		1		
39	$2x^2-3x^2-x^2-3x=0$ $-2x^2-3x=0$		1		
40	$x=1$ $x^2=3x$ $\frac{x^2}{x}=3$ $x=3$		1		

41	$x^3 - x^2 + 3x = 0$ $x + 3x = 0$ $x = -3x$		1		
42	$x^3 - 3x^2 - x^2 + 3x = 0$ $x^3 - 4x^2 + 3x = 0$ $3x = \frac{-x^3 + 4x^2}{3}$		1		
43	$x^3 - 3x^2 - x^2 + 3x = 0$ $x^3 - 4x^2 + 3x = 0$ $-3x = -3x$ $x^3 - 4x^2 = -3x$ $4x^2 = 4x^2$ $x^3 = 1x$		1		
44	$(x-1)x(x-3) = 0$ $x(x - 3 + x - 1) = 0$ $x(2x - 4) = 0$ $2x^2 - 4x = 0$ $2x(x-2) = 0$		1		
45	$x^3 - 3x^2 - x^2 + 3x = 0$ $x^3 - 4x^2 + 3x = 0$ $\frac{x^3}{x} - \frac{4x^2}{x} \frac{3x}{x} = 0$ $x^2 - 4x - 3 = 0$ $x^2 - 4x = 3$ $x^2 = 4x - 3$ $x = \sqrt{4x - 3}$		1		
46	$x \neq 0$ $x = 3$ $x \neq 1$		1		
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 9			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$x=0$ $x=1$
1	$x=0$ $x=1$	32	10	42	
2	$x=\sqrt{x}$	3	5	8	
3	$x\neq 0$ $x=1$	3		3	
4	$x=1$	3	9	12	
5	$x=x^2$	3	2	5	
6	$x=1$ *forgot* $x=0$	1	2	3	
7	$x=x^{\frac{1}{2}}$	3	6	9	
8	$2=0$	1		1	
9	$x=\pm\sqrt{x}$	1		1	
10	$x\sqrt{x}$	1		1	
11	$x=\pm\sqrt{x^2}$	1		1	
12	$x=-1$ $x=\pm 1$		1	1	
13	$\sqrt[\frac{1}{2}]{x^2}=x$ $x=x$		8	8	
14	$x=2$		2	2	
15	$x(x-1)$		2	2	
16	$x=\frac{x}{x}$ $x=0$ $x=1$		2	2	
17	Rewrote question		6	6	
18	Didn't answer		2	2	
19	$(x-1)(x+1)=0$ $x=\pm 1$		1	1	
20	$\frac{x^2}{x}=0$ $x=0$		1	1	
21	$(x-1)(x+1)$		1	1	

22	$2x = x^{-1}$ $x = \frac{x^{-1}}{x}$ $x = 2x$		1	1	\
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 10			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$x=-1$
1	$x=-1$	18	13	31	
2	$x+1$	22	8	30	
3	$x=1$	2	7	9	
4	x	3	14	17	
5	$x=0$	1	2	3	
6	$x-1$	1	5	6	
7	$x=0$ $x=1$	2	1	3	
8	$x=-1$ $x=1$	2		2	
9	Didn't answer		3	3	
10	$\frac{x^2-x=x}{1-1}$ $=$		1	1	
11	$-1-1=2$ $x=2$		1	1	
12	$x^{2-1}+2$ $x+2$ $x=-2$		1	1	
13	$x^2-1-x+1=0$ $x^2=x$		1	1	
14	$x^2-1(-)+x-1$ $x^2-x-1+1$ $=x^2-x$ $x=x^2$ $x=\sqrt{x}$ $x=x^{\frac{1}{2}}$		1	1	
15	Rewrote Question		3	3	
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 11			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$x=\frac{ab}{b-a}$
1	$x=-\frac{1}{2}$	1		1	
2	$x=\frac{ab}{b-a}$	2		2	
3	$x=a+b$	9	12	21	
4	Didn't answer	7	5	12	
5	$x=\frac{ab}{b+a}$	6	3	9	
6	$x=1$	1		1	
7	$x=\frac{b^2-bx-x^2-xb}{bx}$	1		1	
8	$\frac{ba-xa-xb}{xba}=x$	10		10	
9	$ab=xb+ax$	1		1	
10	$x=0$	1		1	
11	$\frac{ab-ax-bx}{xba}=0$	2		2	
12	$\frac{1(ba)1(xa)1(xb)}{xba}$	1		1	
13	$\frac{-x-a-x-b}{x}$	1		1	
14	$\frac{xb}{xab}$	1		1	
15	$a(b-x)-xb$	1		1	
16	$x=\frac{ab}{a-b}$	1		1	
17	$\frac{b-x}{xb}=\frac{1}{a}$	1		1	
18	$x=a$	1		1	
19	$x=\frac{ab+1}{b}$	1		1	
20	$ab^2x^3=1+1$	1		1	
21	$ab-ax-xb=0$	2	2	4	
22	$x-b-a=0$	1		1	
23	$x=\frac{xb}{2}$		1	1	
24	$x=b-a$		1	1	

25	$x=\frac{ab}{2}$		1	1	
26	$\frac{1}{ab}-\frac{1}{b}$ $=\frac{1}{a}$		3	3	
27	$x=\frac{-a}{b}$		1	1	
28	$x=ba$		1	1	
29	$\frac{1}{ab}-\frac{1}{b}=\frac{1}{a}$		1	1	
30	$=x^{-1}-b^{-1}a^{-1}$ $=\frac{1}{x-b+a}$		1	1	
31	$\frac{1}{x}=\frac{2}{a+b}$		1	1	
32	$\frac{ab}{abx}-\frac{ax}{abx}+\frac{b}{abx}=0$ $\frac{ab-ax+bx}{abx}$		3	3	
33	$-(1-b)-(1-a)+1=x$		1	1	
34	$\frac{x}{1}+\frac{b}{1}-\frac{a}{1}=0$ $\frac{xba}{3}=0$		1	1	
35	$\frac{ab-ax-xb}{x-b-a}=0$		1	1	
36	Rewrote Question		7	7	
37	$\frac{1}{x}-\frac{1}{b}-\frac{1}{a}=0$		2	2	
38	$x=\frac{1}{b}-\frac{1}{a}$		2	2	
39	$(x-1)-(b-1)=(a-b)$ $bx+1x=1b=(a-b)$ $x(b+1+b)=(a-b)$ $x(b+1)^{-b}=a+b^{-b}$		1	1	

40	$=\frac{1}{x}-\left[\frac{1}{b}\times\frac{1}{a}\right]$ $\frac{b}{a}-\frac{1}{x}$ $\frac{1}{x}=\frac{b}{a}$ $\frac{1}{2}x=\frac{b}{a}$ $x=\frac{2b}{2a}$		1	1	
41	No Solution		1	1	
42	$xb=ax-ab$ $xb-ax+ab=0$ $xb-ax=ab$ $x=-1$		1	1	
43	$\frac{1}{x}=\frac{1}{a}+\frac{1}{b}$		1	1	
44	$\frac{1}{xb}=\frac{1}{a}$ $\frac{xb}{b}=\frac{a}{b}$ $x=\frac{a}{b}$		1	1	
45	$x=a-b$		1	1	
46	$\frac{ab-ax-xb}{axxba}$ $=xb$ $=\frac{1}{xb}$		1	1	
47	$\frac{1}{x}=\frac{1}{a}+\frac{1}{b}$ $x=\frac{1}{a}+\frac{1}{b}\times-1$		1	1	
48	$\frac{-1}{b}=\frac{1}{a}\times\frac{x}{1}$ $=\frac{-1}{b}=\frac{x}{a}$ $x=\frac{a}{1}=\frac{1}{b}$		1	1	

49	$\frac{1}{x}=\frac{1}{a}-\frac{1}{b}$		1	1	
TOTAAL		52	61	113	

TRIMESTER 1&2: PHASE 1&2

PHASE 1: Question 12			PHASE 2	PHASE 1 & 2	CORRECT ANSWER
Misconception	**Different Answers**	**TOTAL STUDENTE ANSWERED**	**TOTAL STUDENTE ANSWERED**		$(x+y)(3x+y)$
1	$x=\pm\frac{\sqrt{-y}}{3}$	1		1	
2	$((2x+y)-x)((2x+y)+x)$	4	1	5	
3	$(4x-x)(x+y)$	1		1	
4	$(3x+y)(x+y)$	17	8	25	
5	$(2x-x)(y-y)$	1		1	
6	$(3x^2)+y(4x+y)$	1		1	
7	$3x^2+4xy+2y$	1	1	2	
8	$3x^2+4xy+y^2$	9	17	26	
9	$=x(2x^3+y^2)$	1		1	
10	$x^2(4-1)+y(4x+y)$	1		1	
11	$3x^2+y^2$	1	1	2	
12	$(2x+x)(2x-x)(4x+y)$	1		1	
13	$4x+2xy+2xy+y^2-x^2$	1		1	
14	$4x(x+y)+(y-x)(y+x)$	1	1	2	
15	$3x^2+4xy$	1		1	
16	$2x+y=k$ $k-x^2$	1		1	
17	$(x+y)(x-y)$	1		1	
18	Didn't Answer	1		1	
19	$(2x+y)(2x+y)-x(x)$	1	3	4	
20	$(4x+y)(4x+3y)$	1		1	
21	$(2x+y^2)$ $(2x-x^2)$	1		1	
22	$8x^2+4xy-x^2$	1		1	
23	$(y+3)(y+1)$	1		1	
24	$4x^2+y^2-x^2$	1		1	
25	$2x^3(-x-3y)$	1		1	
26	$2x^2+4xy+y^2-x^2$		1	1	
27	$2x^2+y^2-x^2$ x^2+y^2		3	3	
28	$4x^2+y^2-x^2$ $4+y^2$		1	1	

29	$4x^2 + y^2 - x^2$ $4 + y^2$		1	1	
30	$4x + y^2 - x^2$ $4x - x^2 + y^2$ $4x + y^2$ $(y + 2x)(y - 2)$		1	1	
31	$(2x + y)(2x - y) - x^2$ $4x^2 - y^2 - x^2$ $3x^2 - y^2$		1	1	
32	*Simplify* *wrong* $4x^2 + 4xy + y^2 - x^2$ *similar* *terms* *factorise* : *grouping* $(x + y)(4x + 1)(y - 2)^2$		1	1	
33	$2x + y^2 - x^2$ $2xy^2 - x^2$ $x - x = 0 - 2 - y^2$ $= y$		1	1	
34	$1(2x^2 + y^2 - x^2)$		1	1	
35	$x^2(2x + y)(2x - y)$		1	1	
36	$4x + 2xy + 2xy + y^2 - x^2$ *Grouping* $x(4 - x) + y(4x + y)$		1	1	
37	$2x^2 + 4xy + y^2$ $2x(x + 2y) + y^2$ $(2x + y^2)(x + 2y)$		1	1	
38	$2x^2 + y^2 - x^2$ $3x^2y^2 - x^2$ $2x^4y^2$		1	1	
39	$4x^2 - x^2 + y^2$		1	1	
40	$3x^2 + 4xy + y^2$ $x(3x + 4y) + y(y)$		2	2	
41	$(3x - y)(x - 1) = 0$		1	1	

42	$3x^2 + 4xy + y^2$ $y^2 = -3x^2 - 4xy$ $y = \sqrt{-3x^2 - 4xy}$		1	1	
43	$3x^2 + 4xy + y^2 = 0$ $4xy - 3x^2 - y^2 + y^2$ $3x^2 + 3x^2 - y^2 + y^2$ $3x^2$		1	1	
44	$4x^2 y + 4xy + 2xy + y^2 - x^2$ $4x^2 + 6xy + y^2 - x^2$ $x(4x + 2y)x(x - 4y)$		1	1	
45	$4x + 2xy + 2xy - y^2 - x^2$ $4x + 4xy - y^2 - x^2$ $x(4 + 4y - y^2 - x)$		1	1	
46	$4x^2 + 2xy + 2xy - y^2 - x^2$ $3x^2 + 2xy + 2xy - y^2$ $x(3x + 2y) + y(2x + y)$ $(x + y)(3x + 2y)(2x + y)$		1	1	
47	$2x^2 + 4x + 2y + y^2 - x$ $2x^2 + 3x + y^2 + 2y$ $(2x - y)(x + 4xy - y)$ $= \frac{2x}{x} = \frac{y}{2}$ $x = \frac{1}{2} y$ $x = -4xy + y$		1	1	
48	$3x^2 + 4xy + y^2$ $(3x - y)(x -) = 0$		1	1	

49	$2x^2+y^2-x^2$ $3x^2+y^2$ $3(x^2+y^2)$ $3(x+1)(x-1)+(y+1)(y-1$		1	1	
50	$2x^2+y^2-x^2$ $=y^2+2$		1	1	
51	$(2x+y)(2x+y)-x^2$ $(2x+y)(2x+y)=x^2$ $x=\sqrt{(2x+y)(2x+y)}$		1	1	
TOTAAL		52	61	113	

1 About the test

Please read the instructions carefully.

2 Demographics – Personal

2.1 In which age group do you fall?

24 and less	25-34	35-44	45-54	55+
1	2	3	4	5

2.2 Gender

Male 1	Female 2	Prefer not to state 3

2.3 How would you describe your cultural background?

Asian 1	Black 2	Coloured 3	Indian 4	White 5	Other 6	Prefer not to state 7

Please specify if 'Other'

2.4 What is your home language?

Afrikaans	1
English	2
isiNdebele	3
isiXhosa	4
isiZulu	5
Sepedi	6
Sesotho	7
Setswana	8
siSwati	9
Tshivenda	10
Xitsonga	11
Other	12

Please specify if 'Other'

2.5 Which language do you use in learning?

Afrikaans	1
English	2
isiNdebele	3
isiXhosa	4
isiZulu	5
Sepedi	6
Sesotho	7
Setswana	8
siSwati	9
Tshivenda	10
Xitsonga	11
Other	12

Please specify if 'Other'

2.6 Where were you born?

Country	Province	District	Town/City

2.7 Where are your parents living?

Country	Province	District	Town/City

2.8 Which mining company gave you a learnership?

Company	Province	Private student

2.9 When last did you receive education in a class environment?

Year	Province	Town/City

2.10 What type of devices do you have access to? Tick all that apply.

Mobile phone	1
Tablet without internet connection	2
Tablet with internet connection	3
Laptop without internet connection	4
Laptop with internet connection	5
Desktop computer without internet connection	6
Desktop computer with internet connection	7
DVD player	8
Memory Stick	9

2.11 Where do you have access to the internet? Tick all that apply

At home	At work	Public library	Internet cafe	Mobile device	Other
1	2	3	4	5	6

If 'Other', please specify

Algebra test

Simplify expressions 1-5 as fully as possible, showing all your calculations. Note that some of the questions may not be able to be simplified. If this is the case, simply rewrite the expression in the space provided for the answer.

Question		Calculation
1.	$\frac{100}{98}$	
2.	$\left(\frac{1}{2}\right)^{-3}$	
3.	3^x x 3^x	
4.	2^x+2^x	
5.	a^bx a^c	

Solve equations 6-12 for x:

6.	$x^2 = 81$	
7.	$x^2 - 4x = 0$	
8.	$(x-1)(x^2-3x) = 0$	
9.	$x^2 = x$	
10.	$\frac{x^2-1}{x-1} = 0$	
11.	$\frac{1}{x} - \frac{1}{b} = \frac{1}{a}$	

Factorise:

12.	Factorise: $(2x + y)^2 - x^2$	

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Ethics Committee
Tel +27 18 299 4850
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Email Ethics@nwu.ac.za

ETHICS APPROVAL OF PROJECT

The North-West University Ethics Committee (NWU-EC) hereby approves your project as indicated below. This implies that the NWU-EC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title : Using ICTs in an ODL programme

Project Leader: Dr J Kruger
Student on project: SC Beukes and C Beukes

Sub title of project: Using a range of ICT's in assisting facilitators and students in teaching and learning

Ethics number:

N	W	U	-	0	0	1	0	9	-	1	1	-	S	2
Institution				Project Number						Year			Status	

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

Approval date: 2013/03/07 **Expiry date:** 2018/03/07

Special conditions of the approval (if any): None

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 project leader (principle investigator) must report in the prescribed format to the NWU-EC:*
  - *annually (or as otherwise requested) on the progress 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.*
- *The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-EC. Would there be deviated from the project protocol 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-EC and new approval received before or on the expiry date.*
- *In the interest of ethical responsibility the NWU-EC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the project;*
  - *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 NWU-EC 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.*

The Ethics Committee 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 Ethics Committee for any further enquiries or requests for assistance.

Yours sincerely

Prof Amanda Lourens
(chair NWU Ethics Committee)

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Mr P Sago
CEO NCRFET College
CENTRAL OFFICE
TEL: 054-331 3836
FAX: 054-331 3966
E-MAIL: sagop@cen.ncrfet.co.za

21 January 2013

Dear Mr. P. Sago

Permission to do research

I hereby request permission to do research at the Northern Cape Rural Further Education and Training (NCRFET) College. The aim of this study is to do research for my dissertation to complete a M Ed degree at the North-West University. The title of the research project is:

Screencasts as learning and teaching tools in an engineering course: A case study

The N2 students will complete the Determining and Interpreting Resistive Electric Circuits Concepts Test (DIRECT). Interviews will then be conducted with selected students. I will then develop screencast to address the identified misconceptions. The screencasts will be implemented with the distribution of DVDs to all the students. At the end of each trimester the researcher will interview the students using a similar set of questions the set used in the first phase. A semi-structured open-ended questionnaire will be given to the students to determine their perceptions of the value of the screencasts as a cognitive learning tool in an authentic learning environment.

The guidelines of the NWU ethical committee will be followed which in turn ensures complete confidentiality. I will obtain permission from the head of NCRFET College and informed consent from the students.

Yours sincerely

Me C. Beukes
Student number: 11160454
Telephone number: 0825530155

Dr J Kruger
Senior Lecturer/ Study leader
018 299 4589

APPROVAL FORM

I, P. Sago CEO of the Northern Cape Rural FET College hereby approves your request to carry out the study describe above.

....

P. Sago CEO NCRFET

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24 JAN 2013

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21 January 2013

Me. M.M. Reed
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Hans Coetzee ave.
Kathu
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🖷: 053-723 3091
micheller@kat.ncrfet.co.za

Dear Me.Reed

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Yours sincerely

Mr C Beukes
Student number: 11160454
Telephone number: 0825530155

Dr J Kruger
Senior Lecturer/ Study leader
018 299 4589

APPROVAL FORM

I, M. Reed Campus Manager NCRFET College: Kathu Campus hereby approves your request to carry out the study describe above.

KATHU CAMPUS
Private Bag X504, Kathu
24 JAN 2013
KATHU KAMPUS

....

M. Reed Campus Manager NCRFET College: Kathu Campus

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Yours sincerely

Me S.C. Beukes
Student number: 11105976
Telephone number: 0825530156

Dr J Kruger
Senior Lecturer/ Study leader
018 299 4589

APPROVAL FORM

I, M. Reed Campus Manager NCRFET College: Kathu Campus hereby approves your request to carry out the study describe above.

....

M. Reed Campus Manager NCRFET College: Kathu Campus

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21 January 2013

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Beukes

Me S.C. Beukes
Student number: 11105976
Telephone number: 0825530156

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Senior Lecturer/ Study leader
018 299 4589

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P. Sago CEO NCRFET

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PostNet suite 79

Kuruman

6 May 2013

Dear Participant,

I am registered for the M.Ed. degree at the North-West University. As part of my studies I have to complete a research project.

I would thus appreciate your participation. Participation is voluntary and you have the right to withdraw from the study at any time, without fear of being penalised. Your responses will be treated with confidentiality.

I request you to please complete the following test. Interviews will then be conducted with selected students. I will then develop screencasts to address the identified misconceptions. The screencasts will be implemented with the distribution of DVDs to all the students. At the end of the trimester the researcher will interview the students using a similar set of questions as the set used in the first phase. A semi-structured open-ended questionnaire will be given to all the students to determine their perceptions on the value of the screencasts as a cognitive learning tool in an authentic learning environment.

Any enquiries may be addressed to:
Dr Janette Kruger
Senior lecturer: Research Methodology
North-West University, Potchefstroom campus.
Private Bag, x6001, Potchefstroom, 2520
E-mail: janette.kruger@nwu.ac.za

Thank you.

Sanet Beukes

Student: .... Date:______________________________

Consent:

I, the undersigned, ____has read and fully understand the conditions of the project and I hereby declare that I am participating voluntarily in the project.

Signed:

_______________________________________ Date: _______________________________

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Remember you can choose to stop responding or skip a question you don't want to answer.

Just circle the appropriate answer.

1. Have you viewed the screencasts provided to you on the DVD?
   a. Yes.
   b. No.

If you answered "No" what is the reason for not using the screencasts?

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2. Are screencasts easier to understand than the text book? Give just one reason for your answer.
   a. Yes.
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   b. No.
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3. Do you want the screencast done in typing or handwriting?
   a. Hand writing.
   b. Typing.

4. How many times did you use the screencast?
   a. 0 times.
   b. 1 – 2 times
   c. 3 – 4 times
   d. More than 5 times.

5. For what purpose did you use the screen cast?
   a. Revision for test / exam.
   b. To get more clarity on a specific concept.

6. Overall, how favourable or unfavourable is your opinion of the videos? Please choose **ONLY ONE** response:
    a. Poor.
    b. Fair.
    c. Good.
    d. Very Good.
    e. Excellent.

7. How useful do you find the videos? Please choose **ONLY ONE** response:
    a. Not at all useful.
    b. Somewhat useful.
    c. Neutral
    d. Useful
    e. Very useful.

8. What things do you like most about the videos (if anything)? Please choose **UP TO THREE** responses:
    a. Personalized answer to my question.
    b. Demonstration of how to find what I need.
    c. Length of time it takes to watch.
    d. Ability to watch it more than once.
    e. Ability to see what the lecturer is doing.
    f. Ability to hear the lecturer's instructions.
    g. Don't know.
    h. Other. ____

9. What things do you like least about the videos (if anything)? Please choose **UP TO THREE** responses:
    a. Videos are too short.
    b. Difficult to see / hear what's going on.
    c. Video does not play for me
    d. Length of time it takes to watch
    e. Don't know.
    f. Other. ____

10. What recommendations do you have to improve the screencasts?

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