

An investigative study on the affect and concerns of Mathematics student teachers with special reference to social-context based learning packages

by

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in

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North-West University

Promoter: Prof. H. D. Nieuwoudt

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DECLARATION

“I declare that the thesis which I hereby submit for the degree

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at the North-West University (Potchefstroom) is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.”



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Yours sincerely

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We hereby confirm that the Statistical Consultation Service of the North-West University has analysed the data and assisted with the interpretation of the results.

Kind regards

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Dear Mr Hassan

I refer to your letter dated 24 January 2011. Your request to conduct your studies at the Galeshewe campus of the NIHE (as part of your institutional investigation with the current cohorts of Mathematics student teachers) is granted. Please be assured of our support and the availability of whatever amenities are needed by you to aid/facilitate your studies.

Best wishes

A. du Plessis

Dr A. Du Plessis

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25 January 2011

Dear Mr Hassan

PERMISSION TO UNDERTAKE RESEARCH

Your application to undertake for the purpose of your PhD study in Mathematics Education an investigation involving Mathematics Education students of the School of Curriculum-based Studies on the Potchefstroom Campus of the North-West University refers.

After consultation with the chair and relevant members of the Subject Group Mathematics Education, I wish to inform you that we grant you the consent as requested in your letter (dated 19 January 2011) on condition that:

1. The students are informed fully about the nature and purpose of the investigation.
2. The participation of students at all times is voluntary.
3. All data gathered are used confidentially and for the purpose of your investigation only.
4. You contact the relevant lecturers to make the necessary arrangements.

We wish you all success in your endeavour.

Yours sincerely

A handwritten signature in black ink, appearing to read 'B Richter'.

Prof BW Richter
Acting Dean: Faculty of Education Sciences
Director: School of Curriculum-based Studies

OPSOMMING

Hierdie ondersoekende studie is teen die agtergrond van die onlangse oproep, *terug na die basiese*, deur die Schooling 2025-inisiatief onderneem, asook om die 2000 en 2009 Oorsigkomitees se verslae ten opsigte van die opleiding en ontwikkeling van onderwysers en die veranderlike gehalte van leerondersteuningsmateriaal aan te spreek. Die sistemiese transformasie het gelei tot twee kurrikulumhersienings wat binne die Suid-Afrikaanse onderwyssektor plaasgevind het en het onvermydelik uitgeloop op die identifisering van tekortkominge in die ontwikkeling van onderwysers en leermateriaal. Hierdie studie was geïntegreer om hierdie tekortkominge op die voordiensnemingsvlak aan te spreek deur Wiskunde-studentonderwysers as voornemende Wiskunde-onderwysers voor te berei.

Om die kwessie van *onvoldoende opleiding* aan te spreek was die fokus van die studie nie net op kognisie nie, maar ook op hoe affek die leer van wiskunde kan beïnvloed en sodoende 'n meer omvattende benadering te verseker tot hoe studentonderwysers wiskunde leer en doen. Geïntegreerde navorsing op affek en kognisie kan lei tot optimale prestasie in die onderrig en leer van wiskunde, en navorsers in wiskunde-onderwys behoort die rol en impak van die affektiewe domein erken en dit in die studies op kognisie integreer. Indien leerders bevoegde Wiskundeleerders gaan word, sal hul affektiewe response teenoor Wiskunde baie meer intens wees as wanneer daar slegs verwag word dat hulle op bevredigende vlakke in lae-orde wiskundige vaardighede presteer. In die studies oor wiskunde-kognisie, is die fokus van wiskundige bevoegdheid op vermoëns en bekwaamheid terwyl vanuit die affektiewe domein bevoegdheid in wiskunde meer is as net die vermoëns om waarneembare take uit te voer. Intendeel, die fokus van affektiewe bevoegdheid lê in die rigting, die graad en die vlakke van die intensiteit van affekkonstrukte (of die veranderlikes) wat wiskundige bevoegdheid binne die affektiewe domein sal definieer. Bewysende (kwalitatiewe) data van hierdie studie ondersteun die bewering dat affek die leer van wiskunde beïnvloed aangesien daar duidelike patrone in die algemene uitdrukkings van die deelnemers voorgekom het, veral oor hierdie aspek van die navorsing. Die erkenning van die besorgdhede van studentonderwysers tydens veldpraktikum kan moontlik daartoe lei om die versagting van hierdie besorgdhede aan te spreek, veral die identifisering van waaroor studentonderwysers die meeste besorgd was tydens die onderrig van Wiskunde en hoe, deur hierdie probleme aan te spreek, kan help om hul onderrig-vaardighede en vermoëns te verbeter.

Gebaseer op die kwantitatiewe bewyse is die drie sub-skale van *self*, *taak* en *impak* wat in die Student Concerns Questionnaire (SCQ) gebruik is, verander op die basis van faktorontleding na 'n tweefaktormodel (*besorgdheid oor self-voordeel* en *besorgdheid oor leerlingvoordeel*). Sommige van die statistiese resultate is geïntegreer met die narratiewe data om substantiewe ondersteuning aan die uitdrukkings van studentonderwysers te voorsien. Geen klassieke tendense, soos wat in die besorgdteorie voorkom, is in hierdie studie opgemerk nie. Dit was statisties afgelei dat 'n meerderheid van die Wiskunde-studentonderwysers wat aan die studie deelgeneem het, middelmatig besorgd was met die meeste van die besorgdstellings wat in elk van die items op die SCQ voorgekom het. Om die *veranderlike kwaliteit van die leermateriaal* aan te spreek, het die studie gefokus op die ontwikkeling en die gebruik van sosiale konteksleerpakkette. Die benutting van hierdie leerpakkette (in 'n intervensiestrategie) was gemik op die versterking van sosiale kontekskenis en onderwys, en om die rol in die verplasing (indien enige) van studentonderwyserbesorgdhede binne 'n hiërargiese spektrum te verken. Die bewyse oor hoe studentonderwysers die gebruik van hierdie leerpakkette waarneem, is tydens die onderhoude opgeneem. Ontledings van die verbale data het aangetoon dat die deelnemende studentonderwysers saamgestem het met die gebruik van sosiale konteksleerpakkette as deel van hul Wiskundelesse. Ter opsomming, die behoefte om doeltreffende Wiskunde-onderwysers op te lei en om die akademiese kaliber van voornemende Wiskunde-onderwysers te verbeter was fundamenteel tot die algehele ontwerp van hierdie studie. Daar word vertrou dat kurrikulumbeplanners en -ontwerpers die aanbevelings van hierdie studies sal oorweeg om die sogenaamde tekortkominge binne die onderwysstelsel van Suid-Afrika aan te spreek.

Woorde vir indeksering:

Schooling 2025-inisiatief, leerondersteuningsmateriaal, sistemiese transformasie, kognisie, affek, kurrikulumhersienings, onvoldoende opleiding, studentonderwyser, wiskundige bevoegdheid, veldpraktikum, besorgdheid, faktorontleding, besorgdteorie, leerpakkette.

Titel: 'n Ondersoekende studie op die affek en besorghede van Wiskunde-studentonderwysers met spesiale verwysing na sosiale-konteks gebaseerde leerpakkette

SUMMARY

This investigative study was undertaken against the background of the recent calls for *back to basics* by the Schooling 2025 initiative, as well as to address the 2000 and 2009 Review Committees' reports on the training and development of teachers and on the variable quality of learning support materials. The act of systemic transformation has led to two curriculum revisions taking place within the South African education sector and has inevitably culminated in the identification of shortcomings in teacher development and learning materials. This study has positioned itself to address these shortcomings at pre-service level through the preparation of Mathematics student teachers as prospective Mathematics teachers.

In addressing the issue of *inadequate training*, the focus of the study was not only on cognition, but also on how affect could influence the learning of Mathematics so as to ensure a more encompassing approach in understanding how student teachers learn and do Mathematics. Integrated research on affect and cognition could lead to optimal performance in the teaching and learning of Mathematics and researchers in mathematics education need to acknowledge the role and impact of the affective domain and integrate it into studies of cognition. If learners are going to become competent learners of Mathematics, their affective responses to Mathematics are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low-order mathematical skills. In the studies on mathematics cognition, the focus of mathematical competencies is on abilities and capabilities while, in the affective domain, competencies in mathematics are more than the abilities to perform observable tasks. Rather, the focus of the affective competencies lies in the direction, the degree and the levels of intensities of affect constructs (or their variables) that will define mathematical competencies within the affective domain. Evidentiary (qualitative) data from this study supported the contention that affect does influence the learning of mathematics since there were distinct patterns in the overall expressions of participants towards this aspect of the research.

The acknowledgment of the concerns of student teachers during field practicum could possibly help in ameliorating these concerns through the identification of what student teachers were mostly concerned about when teaching Mathematics and how, by addressing these concerns, could

help improve their teaching skills and abilities. Based on the quantitative evidence, the three subscales of *self*, *task* and *impact* used in the Student Concerns Questionnaire (SCQ) were modified on the basis of factor analysis to a two-factor model (*concerns about self-benefit* and *concerns about learner-benefit*). Some of the statistical results were integrated with the narrative data to provide substantive support for the expressions of student teachers. No classical trends, as noted in the concerns theory, could be detected in this study. It was statistically inferred that a majority of Mathematics student teachers who participated in this study were moderately concerned about most of the concerns statements noted in each of the items on the SCQ. In addressing the *variable quality of the learning material* the study focused on the development and the use of social context learning packages. The utilisation of these learning packages (in an intervention strategy) was aimed at strengthening social context knowledge and education, and explored its role in the translation (if any) of student teacher concerns within a hierarchical spectrum. The evidence on how student teachers perceived the use of these learning packages was recorded during the interviews. Analyses of the verbal data revealed that the participating student teachers agreed with the use of social context learning packages as part of their Mathematics lessons. In sum, the need to prepare effective Mathematics teachers and raise the academic calibre of prospective Mathematics teachers was fundamental to the overall design of this study. It is trusted that curriculum planners and designers will consider the recommendations of this study to address the so-called inadequacies within the education system of South Africa.

Words for indexing:

Schooling 2025 initiative, learning support material, systemic transformation, cognition, affect, curriculum revisions, inadequate training, student teacher, mathematical competency, field practicum, concern, factor analysis, concern theory, learning packages.

Title: An investigative study on the affect and concerns of Mathematics student teachers with special reference to social-context based learning packages

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CLARIFICATION OF TERMS AND ACRONYMS

- *Back to basics*: the notion of incorporating the features of a traditional teacher-focused pedagogy.
- *Coding*: an alphanumeric (or otherwise) assignment of questionnaires for purposes of identification and analysis.

- *Constructs*: a concept that is created to represent a collection of concrete forms of behaviour.
- *Curriculum 2005*: a curriculum that is outcomes-focused.
- *Dichotomous*: separation into two divisions that differ from each other.
- *HEIs*: refers to Higher Education Institutions.
- *MATD 411*: Mathematics Methodology module for the FET Phase.
- *Mathematising*: to consider something in, or reduce it to, purely mathematical terms.
- *MTSF*: Medium Term Strategic Framework – it is a statement of intent identifying the development challenges facing South Africa and outlining the medium-term strategy for improvements in the conditions of life for South Africans.
- *National Minister of Basic Education*: as opposed to the National Minister for Higher Education.
- *NIHE*: the National Institute for Higher Educational – declared a legal entity in 2006 by the then Minister of Education, Professor Kader Asmal. Also the site of numerous programme deliveries in the Northern Cape.
- *North-West University*: the accrediting partner institution.
- *RNCS/NCS*: the Revised National Curriculum Statement/National Curriculum Statement – products of the curriculum revisions of Curriculum 2005.

ABEV	Attitudes, Beliefs, Emotions and Values questionnaire
ANA	Annual National Assessment
ANCOVA	Analysis of Co-variance
APE	Adapted Physical Education
CAI	Computer Aided Instruction

CAL	Computer Aided Learning
CAPS	Curriculum and Assessment Policy Statements
CBAM	Concerns-Based Adoption Model
CERI	Centre for Education Research and Innovation
DBE	(National) Department of Basic Education
DoE	(National) Department of Education
ES	Effect Sizes
ET	Experienced Teacher
FET	Further Education and Training
GET	General Education and Training
ICT	Information and Communication Technology
LAMs	Learning Area Managers
LET	Less-experienced Teacher
LOs	Learning Outcomes
LSM	Learning Support Material
MANOVA	Multivariate Analysis of Variance
OBE	Outcomes-Based Education
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
SCQ	Student Concerns Questionnaire
SoCQ	Stages of Concerns Questionnaire
TCCL	Teacher Concerns Checklist
TCQ	Teacher Concerns Questionnaire
UWC	University of the Western Cape

CHAPTER 1

INTRODUCTION AND GENERAL ORIENTATION

1.1 INTRODUCTION

In July 2010 the South African education authorities announced that the outcomes-based curriculum was to be reformed and that the revised curriculum would become part of an initiative known as *Schooling 2025*. This announcement came after years of debate among education and private sector stakeholders about the effectiveness and suitability of implementing a curriculum in South Africa which is primarily outcomes-focused. In order to comprehend this need for curriculum revision, it is placed concomitantly with the priorities listed in the Medium Term Strategic Framework (MTSF) – a guiding framework for government programmes in the electoral mandate period ranging from 2009-2014. According to Soobryan (2010:3), the *Schooling 2025* initiative is about consolidating existing public commitments, as well as acknowledging the new commitments of government as *per* the priorities of the MTSF. Even though curriculum revisions are not new in South Africa, it has to be appreciated against the historical precedents of earlier attempts at systemic transformation and curriculum reformation in an attempt to redress the education imbalances of the past.

Systemic transformation of South African society manifested itself as a neo-liberal process, and in the education and training sector it replaced an education curriculum rooted in past political ideologies. The birth of a reconstructed education system and the successful implementation of an outcomes-focused curriculum were and still are contingent to the stratagems of a politico-educational ideology. (The education initiative *Schooling 2025* is still embedded within the principles of the Constitution and thus concomitant to the political ideology of government.)

The features of one such stratagem are the use of dichotomous parameters for the interpretation of political reality within South African society. These parameters embrace the categories of disadvantaged-advantaged, black-white, rich-poor, communist-capitalist, First World - Third World, apartheid-democracy, and the like. Only the ideologically obfuscated mind will dispute the influences that these parameters have on the present education system in South Africa. Nevertheless, the pro-democratic philosophies still underpinning curriculum revisions are there to prevent divisive ideologies from emerging in our education and training system. The paradigmatic shift within education and training from an ethno-nationalistic ideology to an ecclesiastical adherence (*interpreted in terms of the socio-political vision of the ruling party*) to an outcomes-based curriculum (Curriculum 2005) provided a foundational framework for curriculum transformation (preceding any other reform initiatives in the run-up to the adoption of Curriculum 2005) in South Africa. According to Cross, Mungadi and Rouhani (2002:171), the tensions that dominated the post-apartheid curriculum transformation processes have resulted in a significant paradigm shift on reclaiming knowledge and cognition in the classroom. The Outcomes-Based Education (OBE) model (hereafter referred to synonymously as a *learner-centred* and *activity-based model*), was chosen, accepted and introduced in Curriculum 2005. This new curriculum focus was specifically on aspects such as problem-solving, creativity and the acquisition of skills and attitudes aimed at producing thinking, competent future citizens (DoE, 1996:3) and a further motivation for a learner-centred and activity-based approach to education and training (DoE, 2003:2). Even though it can be argued that OBE-specific is inherently behaviourist in its undertone, its reliance on constructivist and social context underpinnings allows it to transcend to a more pragmatic approach that is more concerned with cognitive outcomes than with theories and principles of teaching and learning. From a mathematics education perspective, even though the priorities and structural re-alignments within curriculum revisions are geared towards the improvement of learner performances, the question arises as to what degree such changes will impact on the achievements of Mathematics learners and whether a cognitive-oriented curriculum (still outcomes-focused under the *Schooling 2025* initiative) is flexible enough in interpretation and implementation to allow for the development and interpretation of mathematical knowledge through varied contexts, epistemologies and ontological orientations. The achievement and performances of Mathematics student teachers and learners can no longer be considered to be embedded only within the constructs of cognition but the influence of affective determinants on achievement and performance are receiving greater prominence than before.

The consideration and the role of the affect on the Mathematics curricula have often been neglected or overlooked (a full exposition of this argument is provided in Chapter 2). Furthermore, the training of student teachers should become more holistic and not just cognitive in approach. One such aspect that should be taken into consideration is the concerns that student teachers have about their own teaching abilities (see Chapter 3). From a South African context and for purposes of this study, the term *student teacher* is taken to refer to a pre-service student teacher studying at a tertiary or Higher Education Institution (HEI) while the term learner or pupil is regarded as being school-based¹.

This chapter provides the background setting for investigating certain conceptual frameworks and related constructs as *per* education research. The theoretical support for this investigation is provided by a preliminary literature review (in this chapter) and elaborated on in the chapters that follow. The literature review covers the field of study of this investigation and the thesis becomes focused on the arguments of the problems identified and culminates in the synthesis of the problem statement. In addressing the problem statement, the research questions are formulated for the investigation, the aims and objectives for the study are identified and the research design and methodology are selected to suit the type of investigation that is undertaken.

1.2 LITERATURE REVIEW AND PROBLEM STATEMENT

As a precursor to the advocacy of *Schooling 2025*, the priorities from the 2009 MTSP relating to school education, identified five development indicators - one of them being the “National Senior Certificate (NSC) pass rate” (SA, 2010:30). In the 2008 NSC examination results, the first cohorts of candidates (exiting from the first complete cycle of OBE) achieved a 62,5 percent pass rate which was 2,7 percent lower than the previous year’s Senior Certificate (a clear distinction exists between the two types of certifications).

¹The use of the word student (especially from an international perspective) in quoted texts may not infer this distinction between student and learner and it is left to the reader to interpret its usage within the context presented in the texts (as was done by this researcher).

According to the then National Minister of Education, Naledi Pandor, the National Senior Certificate and the phased-out Senior Certificate were fundamentally different (Masombuka, 2008:4). Pandor warned the public to avoid the temptation to make simple comparisons between the previous system and the new and stated that the National Curriculum would continue to be criticised, largely for failing in *implementation* and *interpretation*. She announced the intention to launch a vigorous educator² support and development programme (Shonisani, 2008:3). The tacit acknowledgement to address the shortcomings within the curriculum in the wake of the 2008 examination results, has created a portal for constructive debate around curriculum issues which was difficult to initiate previously owing to the denial approach adopted by the ruling party when faced with the contentious issues surrounding the outcomes-based curriculum. The first initiative of education reforms in South Africa focused on changing the school curricula and developing new structures which were needed to support more enlightened approaches to learning. The development of the school curriculum policy and interpretation of policy focused on two areas: curriculum-as-knowledge and curriculum-as-policy. Underlying the essence of curriculum-as-knowledge was the premise of knowledge construction and development through a learner-centred and activity-based approach. In the curriculum-as-policy lineage, the focus was on the symbolic aspects of policy which were primarily political in nature (Chisholm, 2005:194). To place *Schooling 2025* in the context of earlier curriculum revisions entails acknowledging the streamlining of Curriculum 2005 through the construction of the *Revised National Curriculum Statement* [RNCS: for Grades R (*reception year*) to 9] and the *National Curriculum Statement* (NCS: for Grades 10 to 12). The parameters and brief for the first curriculum revision were set out by the *Review Committee on Curriculum 2005* which identified, *inter alia*, the following shortcomings (DoE, 2000:18-21):

1. Inadequate orientation, training and development of teachers and follow-up support systems.
2. Learning support materials that are variable in quality, often unavailable and not sufficiently used in classrooms.

² The term educator is used synonymously with teacher. Recent Department of Basic Education (*herewith referred to as DBE*) documents have reverted back to the use of the word teacher.

In September 2009 a draft report entitled *Report of the Task Team for the Review of the Implementation of the National Curriculum Statement* was presented to the current National Minister of Basic Education, Angelina Matsie Motshekga. The report identified the same two shortcomings above, *inter alia*, as challenges and pressure points particularly with reference to teachers and the quality of learning (DoE, 2009:6). Motshekga reported to the (National) Parliament's Portfolio Committee on Education that outcomes-based education had in many ways failed to provide learners with essential skills that would be needed in the real-world and called for a review of the school curriculum (Motshekga, 2009:2). As a consequence, under the initiative of *Schooling 2025*, certain aspects of the highly criticised outcomes-based curriculum were replaced in a comprehensive turnaround of the schooling sector (*Action Plan 2014: Towards the Realisation of Schooling 2025* – announced by the Minister of Basic Education on 6 July 2010). In order to structure this curriculum revision, the RNCS/NCS was repackaged to become more accessible to teachers and learners. The RNCS/NCS had not been scrapped entirely but had been modified to improve the performance of school learners (DFA, 2010:7).

Lekota (2010:1) states that the *Schooling 2025* initiative has a long-term vision of creating a viable foundation for education and learning. One of the immediate changes brought about in the latest curriculum revision process was the development of a single, comprehensive and concise Curriculum and Assessment Policy Statements (CAPS) for each grade, ranging from grade R to 12. The researcher notes that these new initiatives for curriculum revision seem to be obedient to the call for *back to basics* aimed at improving learner performance. In teacher development, one of the recommendations of the 2009 Review Committee was about the preparation of teachers to support curriculum implementation. Soobryan (2010:21) states that teacher development is the area requiring perhaps the greatest degree of innovation. In addition, Engelbrecht and Harding (2008:69) note that many teachers may not have been sufficiently prepared to teach using methods indicated by the OBE principles.

How well will these teachers then be prepared and trained in the CAPS for its (successful) phase implementation from 2011 onwards? Of concern, nonetheless, are the curriculum revisions that have taken place so far within a short period of time (since the advent of the new democracy in South Africa).

These revisions could be viewed by some to constitute a disservice to the youth and the country as it strives to obtain equitable transformation through changing educational priorities and structurally realigning the national curriculum. By simply focusing on certain problematic aspects of Curriculum 2005/RNCS/NCS (as highlighted by the respective Review Committees) could result in other non-focused components of the outcomes-based curriculum to become problematic later on. Whether the *Schooling 2025* initiative will become a panacea for an outcomes-based curriculum remains to be seen. The problems around inadequate teacher-training and the quality of learner support material have to be addressed, more so in Mathematics, as Mathematics was identified as the only subject in the 2009 MTSF report as a development indicator (by implication the need to monitor improved performance in Mathematics). Consequently, to achieve good matriculation passes, intervention would have to take place in the formative years of the learning of Mathematics, especially by addressing issues around conceptualisation in Mathematics and the re-skilling of learners with the necessary mathematical competencies to deal with problem-solving, mental computational skills, *etc.* The urgency to address these issues could be affirmed by the need to improve learners' mathematics performances in the lower grades. A study was conducted in 2004 whereby tests were administered to a cross-section of Grade 6 Mathematics learners country-wide. [Note: The LOs refer to the five Learning Outcomes in Mathematics in the General Education and Training (GET) band.] The bar graph (see Figure 1.1 – the vertical axis indicates the percentages) indicates the performance levels (% wise) in each of these LOs (depicted along the horizontal axis).

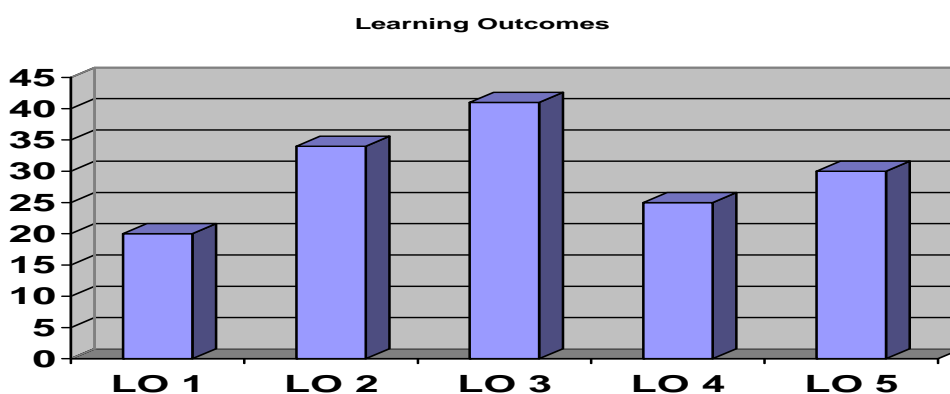


Figure 1.1: Performance by Learning Outcomes

(Figure 1.1: Sourced from DoE, 2005:37)

The country-wide test achievement results at this level (Grade 6) are indeed worrisome because of the low percentages attained for these LOs in Mathematics. Simply put, there is a need for direct intervention to strengthen the foundational knowledge and skills in Mathematics. Attempts to improve basic numeracy in Mathematics through the use of learning and teaching packages, among others, are lodged with the *Foundations for Learning and Teaching* project, an initiative of the DBE for the Foundation Phase (Grades R-3) of the GET band. Further intervention strategies in 2011 have seen the implementation of standardised national workbooks aimed at improving teaching and learning in the Foundation and Intermediate Phases (Grades 1-6), and the introduction of the Annual National Assessment (ANA) programme to measure progress on learner achievement towards the 2014 target of a 60% achievement rate articulated in the *Action Plan to 2014: Towards the Realisation of Schooling 2025* (DBE, 2011a:4).

The results of ANA, conducted in February 2011, revealed an average percentage score for Grade 6 Mathematics at 30% (DBE, 2011a:20). Figure 1.2 illustrates the pre-ANA tests and the ANA tests. [Note: Vertical axis denotes the maximum/minimum performance values and the horizontal axis represents the provinces.] “The left-hand vertical bar for each province represents pre-ANA performance while the right-hand bar represents performance in ANA. The very large difference in the performance of Eastern Cape (EC) in the pre-ANA tests and the ANA tests is clear. For at least four provinces, Free State (FS), Gauteng (GP), Northern Cape (NC) and Western Cape (WC), performance in ANA 2011 could be considered more or less consistent with performance in previous tests.” (DBE, 2011a:21) [Note: NW=North West Province, MP=Mpumalanga Province, LP=Limpopo Province, KN=KwaZulu-Natal Province.]

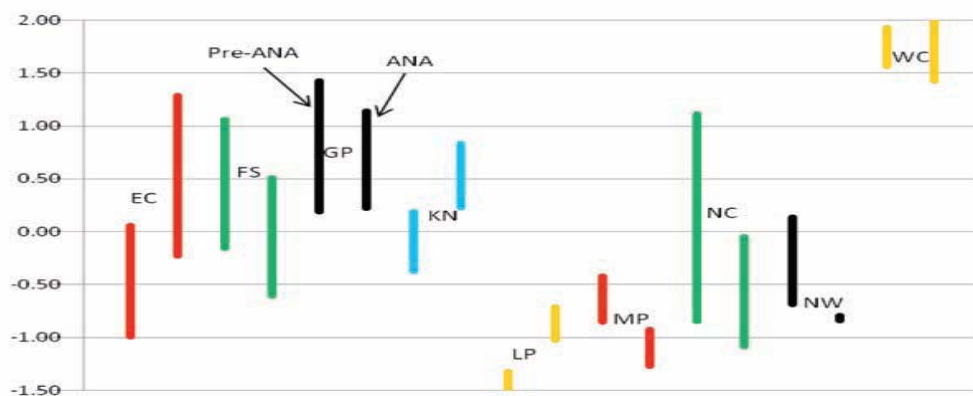


Figure 1.2: ANA against pre-ANA Comparison

(Figure 1.2 sourced from DBE, 2011a:22)

In comparison with the developments to address problems in the formative years of learning Mathematics, no discernible intervention learning packages [as additional to the learning support material (LSM)] for the Senior Phase (Grades 7-9) and even for the Further Education and Training (FET) Phase (Grades 10-12) have been developed as of late. The problems at the higher levels of learning Mathematics are not the focus of basic numeracy or foundational Mathematics but on learners' understanding of conceptual knowledge and algorithmic procedures of formal or abstract Mathematics. Hence, the need exists to explore the development of learning packages to aid the consolidation of mathematical knowledge in the higher grades within a learner-centred/activity-based environment.

Attempts at attaining good results in Mathematics may be viewed against the mathematical preparedness of learners as they develop during their schooling career. The mathematical preparedness of learners who enter Higher Education Institutions (HEIs) has, however, raised the concerns of several researchers for not meeting the expectations of the programmes (Engelbrecht and Harding, 2008:58). Disparity in levels of mathematical preparedness of neophyte students at HEIs needs to be addressed. In particular, the pre-service training of students as future Mathematics teachers may be regarded as the first base to prepare them for the changes to the curriculum, unlike professional teachers who would in all probability have to attend workshops to familiarise themselves with the articles of curriculum revisions. The absence of uniformity in teacher education within the HEIs has also seen diverse approaches in programmes offered for teacher-training (pre-service and in-service training). At present there is still an urgent need to reconceptualise teacher education programmes within the HEIs to ensure the provisioning and development of high quality education. Such reconceptualisation of teacher-training programmes should endorse the need to address teacher quality through their adequate training and development. In the past, teachers complained that most HEIs do not cover the Curriculum 2005/RNCS/NCS thoroughly enough and that newly trained teachers were not competent to teach [as cited in the *Report of the Task Team for the Review of the Implementation of the National Curriculum Statement*] (DoE, 2009:10). At the Education Dean's Forum meeting (2 August 2006), a presentation was made to the forum proposing 10 key proposals for developing a National Framework for Teacher Education in South Africa. These proposals were aimed at addressing problems dealing with teacher education, *inter alia*:

- The qualifications profile not matching the competencies needed.
- Low teacher concept and content knowledge.
- Shortages of quality Mathematics teachers.
- Meeting 21st century teaching and learning needs that encompass the mastery of new technologies and knowledge exchange patterns, as well as the demands of a young and growing democracy.

In preparing student teachers as prospective Mathematics teachers, a spectrum of mathematical competencies should be developed during institutional learning and teaching practice (herewith referred to as field practicum). In South Africa, most teacher-training programmes appear to cater for the cognitive demands of programme outcomes. The perception is that no or minimal consideration is given to the influence of affect on students' learning, as well as the concerns they might experience in the field. Supportive of this perception is the evidence that in all the curriculum revisions that have taken place thus far in South Africa, the focus was on cognitive outcomes, general aims, specific aims and competencies without incorporating aspects of affective outcomes and affective competencies (see paragraph 2.6). The exposition that follows seeks to explicate the need for a modified orientation towards the training of Mathematics student teachers in their preparation as future teachers and addresses two of the problems highlighted by the 2000 and 2009 Review Committees.

In addressing the issues of inadequate training and development, this study proposed a consideration of:

1. *The influence of affect on the learning of Mathematics with special reference to mathematical competencies*

Mathematical competencies can no longer be regarded as performance or achievement indicators that are exclusive to the cognitive domain. It should rather be viewed concomitantly with affective constructs which can be seen as further indicators of the achievement of education outcomes or as predictors of future success (see paragraph 2.6).

According to Goldin (2002a:60) “when learners are doing Mathematics, the affective system is not merely auxiliary to cognition, it is central”. The mid-1990s saw a number of pivotal developments in research on mathematical affect since the key contributions of McLeod. McLeod (1992:576) defined the affective domain as referring “to a wide range of beliefs, feelings and moods that was generally regarded as going beyond the domain of cognition”, and he identified “attitudes, beliefs and emotions as constructs of the affect”. He defines “attitude as the affective responses that involve positive or negative feelings of moderate intensity and reasonable stability (p. 581)”. Beliefs may be defined as psychologically held understandings, premises or propositions about the world that are thought to be true (Philipp, 2007:259). Pintrich and Schunk (2002:280) state that “emotions are often the dependent variable that flows from various cognitive and appraisal processes”. Another affect-related construct, namely values is reviewed in this study and a study of its predictors (proposed by the researcher) is reported on. Schunk (2004:384) posits that “values have a direct link to achievement behaviours such as persistence, choice and performance and may relate positively to many self-regulatory processes such as self-observation, self-evaluation and goal setting”. In assessing the influence of affect on the learning of Mathematics requires delineating its constructs (for purposes of this study), namely beliefs, attitudes, emotions and values into their variables such as *attitudes towards mathematics*, *beliefs about mathematics*, *emotional reactions towards mathematics* and *values about mathematics*.

2. *The use of the Fuller-Brown model for teacher development to assess the concerns of Mathematics student teachers during field practicum sessions*

A three-stage model of concerns was proposed by Fuller in 1969 on the basis of convergences in the empirical literature and of clinical observations (Reed, 1995:56). The research undertaken by Fuller in 1969 was to become a pioneering study on how to conceptualise the concerns of teachers and was first published in the *American Education Research Journal*, and titled *Concerns of Teachers: A Developmental Conceptualization* (Fuller, 1969:201-213; Reed, 1995:51). The model was developed based on interviews with 14 student teachers, written statements from 29 student teachers and a comparison of these student teachers’ concerns to those of experienced teachers expressed in previous studies. Of importance to teacher development were stages two and three of the model.

These two stages were called *Early concerns about self* and *Late concerns about learners* (synonymous with the two-factor model, see paragraph 6.3.2). According to Fuller (1969: 222), “student teachers experienced concerns about survival (low-level concern) because of their first contact with teaching”. Fuller believed that the main objective was to move student teachers from concerns about themselves toward concerns about learners (middle-level concern). In 1975, after collecting and analysing more data, Fuller and Brown re-examined the 1969 model and presented a three-stage model (*herewith referred to as the Fuller-Brown model of teacher development*) that focused on a developmental sequence of concerns from self concerns → task concerns → impact concerns (also referred to as the sub-scales). Fuller and Brown (1975:38) state that teachers in different stages of their careers are more focused on certain concerns. The empirical part of this study utilised the Fuller-Brown model of teacher development.

In addressing the issues of variable Learning Support Material (LSM), this study proposed a consideration of:

3. *The development and use of social context learning packages*

A differentiated approach to contextual teaching in Mathematics was undertaken by student teachers (as part of the empirical study) to elucidate what is prescriptive in curriculum policy and what is the reality (ontology) of contextual teaching in the classroom. This study explored the impact (if any) in the use of social-context based learning packages (herewith simply referred to as social context learning packages) in an intervention strategy to ameliorate the concerns that student teachers might have experienced during field practicum sessions. The proposed use of learning packages (in conjunction with and additional to LSMs) was motivated by the call for a more standardised approach to workbooks as envisaged for *Schooling 2025* (SA, 2010: 18), by providing a more social context orientation to mathematical texts. The focus was to introduce an intervention through the use of topical issues and newsworthy events and to promote the process of mathematisation whereby Mathematics becomes a hermeneutic activity (the theory and practice of interpretation).

The utilisation of these learning activities was monitored by the researcher to gain insight into how Mathematics student teachers interpret mathematical texts from a biased/non-biased perspective.

From an epistemological perspective, the social context construct was the dominant facet considered in the preparation of these learning packages in relation to the development and construction of mathematical knowledge. The interrogation of social context texts will inevitably expose the readers to deal with issues affecting their biased/non-biased interpretations of mathematical context. Care was taken not to perpetuate inequity and cultural, racial, sexist, *etc.* discrimination in the selection of socio-topical issues for use in learning packages. Furthermore, a social contextual environment provided a strong basis for the development of social context knowledge. It was this strong basis that provided the rationale for using learning packages in an intervention strategy in the first place to address the issue of student teacher concerns. In addition, by promoting an interpretative approach for social context education would enable a learner-centred/activity-based environment to find more congruency with certain aspects of critical inquiry and constructivism. Emanating from the preceding arguments noted within the literature review, a description of the problem statement is presented below:

Problem Statement

The investigation was undertaken against the background of recent calls for *back to basics* by the Schooling 2025 initiative, as well as addressing the 2000 and 2009 Review Committees' reports on the training and development of teachers and on the variable quality of learning support materials (DoE, 2000:18-21). The particularisation of mathematics-specific training was strongly supported by the 2009 Review Committee in that the training of teachers should become more subject-specific (DoE, 2009:7-10), as well as the need to improve teachers' content knowledge through training in targeted subject areas (SA, 2010:32). The act of systemic transformation has up to now led to two curriculum revisions taking place in the South African education environment and has inevitably culminated in the identification, *inter alia*, of shortcomings in teacher development and learning materials. This study has positioned itself to address these shortcomings at pre-service level through the preparation of Mathematics student teachers as prospective Mathematics teachers.

In addressing the issue of *inadequate training*, the focus of the study was not just on cognition, but also on how affect could influence the learning of Mathematics [at institutional level – for this study, at the National Institute for Higher Education (Northern Cape), herewith referred to as the NIHE] so as to ensure a more encompassing approach in understanding how student teachers learn and teach Mathematics. In addition, by acknowledging the concerns of student teachers during practicum sessions [at field level – at placement schools in the Northern Cape Province and the North-West Province (see paragraph 5.2.2 – sample demographics)] may possibly help in ameliorating these concerns through the identification of what student teachers were mostly concerned about when teaching Mathematics and how, by addressing these concerns, may help improve their teaching skills and abilities. In addressing the *variable quality of the LSMs*, the study focused on the development and the use of social context learning packages. The utilisation of these learning packages (in an intervention strategy) and within the ambit of a traditional-contemporary pedagogy, was aimed at strengthening social context knowledge and education and explored its role in the translation (if any) of student teacher concerns within a hierarchical spectrum (reference to the Fuller-Brown model for teacher development).

At this present juncture, the study variables (in *italics* below) can now be identified and formulated from the problem statement. Numerous literature studies (see Chapter 2) have alluded to *the influence of affect on the learning of Mathematics*. Chapter 3 provides a theoretical framework for the analyses of *concerns* that student teachers may experience during field practicum sessions. The researcher avers that by focusing this study at the level of pre-service teacher-training, it could help strengthen the mathematical competencies of student teachers as they become an integral part of the investigation on how affect might influence the learning of Mathematics, how concerns might influence their teaching of Mathematics, and how the use of social context learning packages could expose them (students) in dealing with topical issues and newsworthy events in their deliberations with mathematics lesson programmes during field practicum sessions (also see page 136). When entering the teaching profession, it is hoped that this exposure to knowledge on affect, concerns and social context learning packages, can assist neophyte teachers in understanding how and why learners learn Mathematics, and how they as Mathematics teachers are more encompassing in their knowledge of their own teaching that is not only gained from the perspective of cognition but also from affect.

In addressing the problem statement, the two shortcomings, *inter alia*, noted by the 2000 and 2009 Review Committees as being inadequate orientation, training and development of educators, and learning support materials that are variable in quality, provided the rationale for an empirical investigation. It is at the level of pre-service teacher-training that this study has positioned itself to address these two issues through the proposition of the (study) variables that directly impacts on these issues.

In order to empirically address the problem statement, the following research questions need to be answered:

RESEARCH QUESTIONS:

Research Question 1

How do *affect constructs* influence student teachers' learning of Mathematics?

Research Question 2

What are the *concerns* of Mathematics student teachers during the field practicum sessions?

Research Question 3

To what extent does the use of and interaction with social context learning packages during field practicum sessions (in the intervention strategy) play a role in addressing the concerns of Mathematics student teachers at the NIHE?

Research Question 4

Within the theoretical premises and the empirical results of this study, how can the Mathematics student teachers' perceived affect and concerns be addressed at institutional level and at field practicum level respectively?

1.3 AIM OF THE RESEARCH

The aim of the research was to conduct an investigative study on the affect and concerns of Mathematics student teachers with special reference to social-context based learning packages.

The objectives of this study were to:

- 1.3.1 Describe how affect constructs such as attitudes, beliefs, emotions and values impact on student teachers' learning of Mathematics with special regard to promoting the development of mathematical competencies.
- 1.3.2 Explain the use of the Fuller-Brown model of teacher development to determine what the concerns of Mathematics student teachers were during field practicum (whether they were concerns about survival, task or impact) and whether there was any translation within a developmental hierarchy of concerns. An experiment sample (from the NIHE site) and control sample [from the North-West University (NWU- Potchefstroom campus)] were used in a pre-post quantitative measurement format.
- 1.3.3 Describe how the use of social context learning packages (the intervention strategy) impacted on changing the concerns (if any) of the experimental sample of Mathematics student teachers, when engaging in:
 - 1.3.3.1 making decisions (biased/non-biased) on topical issues and newsworthy events;
 - 1.3.3.2 constructively dealing with the Mathematics of the learning packages; and
 - 1.3.3.3 examining thoughtful decision-making on social context issues.

1.3.4 Propose a mathematics programme as part of the teacher-training programme at institutional level that incorporated not only cognition but also affect in the learning programmes for Mathematics. Similarly, at field practicum level, a lesson programme (incorporating the use of learning packages) was proposed to track changes in concerns of Mathematics student teachers during field practicum sessions. (The proposal for a mathematics programme and a lesson programme is further elaborated on in Chapter 7.)

In sum, the following schema outlines the rationale in undertaking this study.

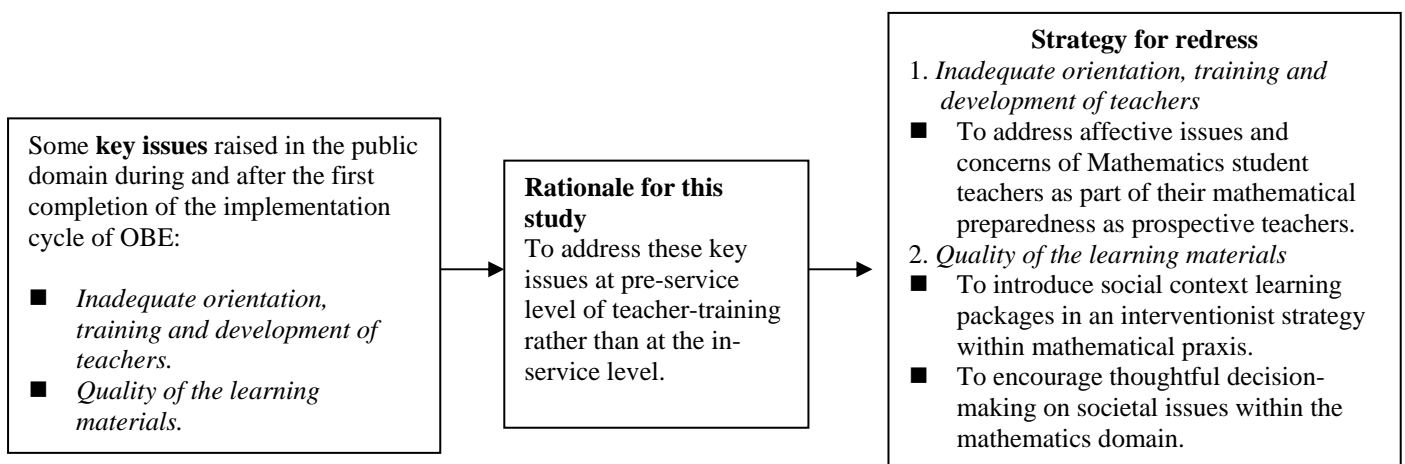


Figure 1.3: Schema of the Rationale for the Study

1.4 RESEARCH DESIGN AND METHODOLOGY

1.4.1 Literature Review

An intensive and comprehensive review of the relevant literature was conducted to analyse and discuss the influences of cognition and affect on mathematics teaching and learning. Different cognitive constructs aligned to outcomes-focused teaching and learning were explored, especially those progressive paradigms focusing on child-centred experiential learning, purpose-centred education, socio-constructivism, critical theory, attribution theories and social context theories.

Affective constructs dealing with attitudes, beliefs, emotions and values as well as concerns theories were explored in the literature study. The criteria used in the development of learning packages were investigated and reported on, as well as on the different social context frameworks. A study of documents, White Papers, Green Papers, presentations, press releases and statements dealing with revisions to the outcomes-focused curriculum was undertaken. A DIALOG search was conducted with the following keywords: mathematics teaching, the learning of Mathematics, mathematics knowledge, social context, socio-constructivism, learner-centredness, learning packages, pre-service student concerns, attitudes, beliefs, emotions, values, pragmatism, teacher education, bias reporting. The use of search engines, *inter alia*, EBSCO-HOST, SABINET and GOOGLE to access journals, articles, conference papers, *etc.*, as well as the NEXUS Database System to profile researchers' field of literature studies and areas of specialisations within mathematics education were explored.

1.4.2 Research Design

An *applied research* design format was adopted in this study that used field survey-type techniques to gather the data (questionnaires/interviews). The selection of this research design was based on the assumptions/perspectives presented in paragraph 1.6. Though the study was qualitative (narrative) in nature, the research design incorporated aspects of quantitative (descriptive and inferential) research. In its entirety, this research design took on a mixed-mode of inquiry (see paragraph 5.2.1).

1.4.3 Research Methodology

1.4.3.1 Population and sample

The study population consisted of Mathematics student teachers from both the NIHE site and the Potchefstroom campus of the NWU. Sampling was done purposively and the sample demographics focused on the dichotomous grouping, namely *Group 1* and *Group 2*.

At the commencement of empirical investigation (in 2011), the composition of Group 1 ($n=40$) consisted of the first-year level up to third-year level Mathematics student teachers based at the NIHE site. Group 1 became the experimental sample for the quantitative part of the empirical investigation and was exposed and subjected to the intervention strategy. The population for Group 2 ($N=100$) consisted of the first-year level up to third-year level Mathematics student teachers based at the NWU (Potchefstroom campus) with participatory samples of $n_1=49$ and $n_2=24$ during the first semester and second semester of 2011 respectively (see paragraph 6.3.3). This group became the control sample and was not part of any intervention. In addition, the study population also incorporated a group of fourth-year Mathematics student teachers that shared dual registration with the NIHE and the University of the Western Cape (UWC) ($n=30$) (see paragraph 5.2.2).

1.4.3.2 Instruments

Qualitative Research Instruments

This research was predominantly qualitative in nature and used the following measuring instruments to aid its qualitative reporting:

1. A 40-item open-ended questionnaire focusing on attitudes, beliefs, emotions and values (the *ABEV Questionnaire* – an acronymic title) within the context of learning Mathematics (see Appendix A).
2. *Interviewing* Mathematics student teachers (Group 1) on their examination, interpretation and teaching of topical issues and newsworthy events when using learning packages. Semi-structured interviews were conducted through the use of an interview guide (see Appendix B). Since learning packages were used in the intervention strategy, interviews were conducted only with the targeted experimental sample at the end of the two field practicum sessions (in 2011).

Trustworthiness of the qualitative research instruments: The technique of triangulation (with literature) was used to ensure the *internal validity* of the student teachers' responses as captured during written feedback and interviews (see paragraph 5.2.3.1).

Quantitative Research Instrument

The following instrument was used for quantitative analyses:

1. A 15-item Likert-type *Student Concerns Questionnaire (SCQ)* (see Appendix C) to assess and examine the concerns of Mathematics student teachers during field practicum sessions. This questionnaire was administered to both the experimental sample (Group 1) and the control sample (Group 2) in a pre-test and post-test format during each of the two field practicum sessions of 2011.

Statistical techniques

Descriptive and inferential statistics were used (for analysing the quantitative data) as it dealt with the description and summarising of the data obtained from the groups used in this study. The means and standard deviations of items within the categories of concerns (referred to in the empirical part of this study as the sub-scales of *self*, *task* and *impact*) were computed (as paired samples – see Appendix M) so as to ascertain which items Mathematics student teachers (from both groups) were mostly concerned about. The quantitative interpretation of this statistical data was done in accordance with a Likert-type scale used in this investigation. Of importance to this study too, was the use of factor analysis to determine how closely various items on the SCQ were related to form sub-scales (factors), with each factor representing several different items on the SCQ (see Appendix C: Information relating to the SCQ). For this study, data was collected from the same respondents (Group 1 and Group 2) under repeated conditions so as to reduce or eliminate individual differences as a source of between group differences. The design included measurements repeated over time (Session 1 and Session 2 of the 2011 field practicum). Since there was a variation between group sample sizes, the possibility of a large error variance existed. Consequently, the use of repeated measures over time provided a way of accounting for this variance and in so doing reducing error variance. The repeated measures Analysis of Variance (rANOVA) was computed for this statistical process. Of equal importance too, was the *practical significance of the differences*. Here Cohen's *d*-value was computed to detect whether the Effect Sizes (ES) of differences in responses between the groups was of practical significance (For further details

of the statistics used, refer to paragraph 5.2.3.2). *Validity and reliability of the measuring quantitative instruments*: The issues on validity and reliability were addressed in Chapter 5 (see paragraph 5.2.3.2).

1.4.3.3 Research procedure

Before the commencement of the empirical study, the *ABEV* and the *SCQ* questionnaires were piloted by this researcher with the UWC sample group identified earlier. The researcher prepared and delivered letters of invitation to the relevant authorities asking for permission for student teachers to participate in this study and for access to placement schools (see Appendices D, E and F). A brief informative session outlining the purpose of the study, as well as guaranteeing confidentiality, was conducted with the Mathematics student teachers prior to the scoring/completion of the questionnaires and interview sessions. The purpose of this exercise was to explain their (student teachers') participation and contribution to this study, as well as the possible potential value of this research. The student teachers were asked not to write their names on the questionnaires so as to ensure that their ratings and responses were treated confidentially. Coded questionnaires (*inductive* and *a priori* coding) were used to distinguish between the responses from the two groups. The interviewing process took place at the NIHE site and transcripts of the responses are in the possession of the researcher. The researcher was solely responsible for administering the *ABEV questionnaire* and conducting the interviews at the NIHE site.

1.5 FIELD OF THE RESEARCH

The core of this research lies in the field of an empowering learning environment that considers the learning and teaching of Mathematics within a learner-centred/task-based/social context paradigm, and considers various constructs (*affect*, *concerns* and *social context* learning packages) in the construction and the development of a mathematics programme and a lesson programme for Mathematics student teachers.

This research is embedded within a post-modernistic approach and focuses on developing an interpretive, critical and constructivist orientation towards the teaching and learning of Mathematics.

1.6 PREMISE OF THE RESEARCH

To further delineate the field of this research, the following assumptions or perspectives are presented to indicate the location or situatedness of this research within:

Ontological Assumptions (dealing with the nature of reality)

The mathematising of topical issues and newsworthy events was approached from an ontological perspective and ran concomitantly with social issues highlighted in the articles or texts. More specifically, an interrogation of the Mathematics and social issues formed the basis for assessing learners' understanding of social context knowledge. Hence this study rejects the *nominalist position* – the doctrine that general or abstract concepts have no existence but only as names or words, and accepts the *realist position* (positivist/modern approach) – where social reality can be understood from an external point of view and that abstract objects have an objective existence (Cohen, Manion & Morrison, 2001:5). This study also rejects *innateness* – that which is present in the mind prior to any experience. The researcher views experience as being acquired through the interaction with different sets of contexts that are internalised and can serve as a contributory factor in knowledge construction and knowledge development.

Epistemological assumptions (relating to how things can be known)

The epistemological assumption for learning is that learners should first learn mathematical concepts and operations before applying them to real-life context. However, Carraher, Carraher and Schliemann (2004:191) posit that “daily human sense” will also guide learners

to find the correct solution intuitively without translating contextual problems into algebraic expressions and that performance on mathematical problems embedded in real-life contexts is superior to that of context-free computational problems (p. 187). As stated earlier in this chapter, mathematical knowledge can be viewed as a social system within the ambit of social constructivism and that a central focus of social constructivism is the genesis of mathematical knowledge, with a key distinction being made between subjective and objective knowledge. The mathematical knowledge of the individual constitutes the subjective, whereas publicly-shared knowledge constitutes the objective. Hence, an interpretive (critical hermeneutics) and constructionist epistemological perspective are assumed for this study that supports a post-modernist orientation (critical and reflective thinking) towards the learning of Mathematics.

Methodological assumptions (dealing with research methods and strategies)

According to Cohen, *et al.* (2001:6), assumptions and perspectives have a significant impact when choosing a research methodology. Since the empirical study was characterised by focusing on individuals (participating student teachers) and understanding student behaviour under situated conditions (institutional and field settings), the study adopts an *idiographic* methodology (specifically the constructivist and interpretative approaches that focus on the uniqueness of the context) as opposed to a *nomothetic* approach that is characterised by procedures and methods aimed at discovering general laws (Maree & Van Der Westhuizen, (2010:33)). The research was undertaken against a naturalistic context (institutional and field context) and the understanding of phenomena (social context) - so as to explore how student teachers understand and impart meaning to their experiences.

1.7 VALUE OF THE RESEARCH

The findings of this study have the potential to change the manner in which we look at cognitive curricula (such as the outcomes-based curriculum) and can prepare prospective teachers to consider the influences of affect on the learning of school mathematics, as well as

to take into consideration the concerns about Mathematics their learners may have. At the HEI level, the added value of the role of affect on the learning of Mathematics and the concerns student teachers have in their ability to teach, can inform or address the often questionable performances of students in Mathematics. The learning packages may be compacted into interactive computer software that can help promote and enhance the use of technology in Mathematics. This type of software will be suitable for Computer Aided Instruction (CAI) and Computer Aided Learning (CAL). There is a definite and urgent need to strengthen and improve the mathematics curriculum in particular, not only through cognitive considerations but also through the role affect can play in the achievement and performances of student teachers, as well as learners of Mathematics. The design of a mathematics programme that incorporates the qualitative measurement of affect in the learning of Mathematics and that can assess the concerns of Mathematics student teachers and the use of social context learning packages, can succinctly contribute to the field of mathematics education and also have the potential to be adapted to other Learning Areas (subjects).

1.8 FEASIBILITY OF THE RESEARCH

The considerations of the influences of affect and concerns on mathematics teaching and learning can contribute to addressing the notion of inadequate preparation and training of teachers, not only from a cognitive perspective, but also help to prepare and expose future teachers to identify other causative factors that lead to poor achievement and performances. On completion of this study, it is the intention of the researcher to workshop the findings of this research with colleagues at the NIHE, provincial education officials such as the Learning Area Managers (LAMs) for Mathematics and the Provincial Co-ordinator for Mathematics. The proposed mathematics programme and lesson programme could be used as generic conduits to develop other subject-orientated programmes or to assist in modify existing programmes.

1.9 ETHICAL ASPECTS OF THE RESEARCH

The Faculty of Education Co-ordinator of the NIHE agreed for this research to be conducted at the institution. At the field level, permission to extend this study to placement schools was sought from the manager of the Frances Baard Educational District in the Northern Cape. Further permission had been applied for from the Dean of the Faculty of Education Sciences of the NWU (Potchefstroom campus) to use the NWU Mathematics students in this study. The study population was addressed by the researcher at both the NIHE site and the NWU campus with regard to obtaining their permission to participate in the study. The brief included informing students about making informed choices as to whether they want to participate voluntarily in the research. The researcher assured these prospective participants of the parameters of confidentiality and clearly outlined the instructions/explanations of their tasks if they did decide to participate. They were also informed about the value of the study and its relation to their (student teachers') field and more specifically their programme of study. This study aligns itself with the guidelines of the ethics procedures as laid down by the Ethics Committee of the NWU (Ethics clearance number for this study: NWU-00113-12-S2). One of the primary ethical norms for this research is based on the search for knowledge and truth, and the avoidance of error. The researcher undertook to acknowledge and promote the following ethical principles (adapted from Resnik (2011:2)):

Honesty: To honestly report data, results, methods and procedures.

Objectivity: To strive to avoid bias in data analysis and data interpretation; to avoid or minimise bias in the selection of topical issues and newsworthy events (for use in social context learning packages).

Carefulness: To avoid careless errors and negligence that may impact negatively on this study.

Openness: To be open to criticism and new ideas. *Respect sources of information:* To acknowledge and honour copyrights and sources of information; to give proper acknowledgement for all contributions made toward this research.

Confidentiality: To protect the confidentiality of the respondents participating in this study.

1.10 REFLECTION ON THE ANTICIPATED RESEARCH PROBLEMS

The researcher anticipated some problems that might have been associated with this study, namely:

Response errors

Misinterpretation or misunderstanding of questions: Taking the respondents' literacy levels into consideration. English might not have been the home language of some of the respondents. The possible emergence of the Hawthorne effect.

Error of central tendency:

Respondents who were hesitant to assign an extreme score (on the Likert-type scale) might have been inclined to rate in the centre of the scale.

Design errors

The researcher recognised certain limitations inherent in the research design. Since this was not a dedicated longitudinal study but rather a "snapshot in time" over two field practicum sessions, it was not possible to state unequivocally a cause and effect relationship between involvement in the study and student success. This study might be difficult to generalise to other types of programme offerings with different settings, requirements and qualifications.

Uncontrolled bias

The more the researcher developed intense scholarly relationships with the participants, the greater the risk of bias that might infiltrate the study.

Trustworthiness of coding data

The researcher acted as the single coder for the data collected that might not be in defence of greater trustworthiness in coding data since multiple coders are usually used to obtain higher inter- and intra-coding reliability.

1.11 SCHEMA FOR THE OVERVIEW OF THE STUDY

The following schema provides an overview and intent of this study. A brief synopsis of each chapter is given and its perceived coherency is in the diagrammatical representation as outlined in Figure 1.4.

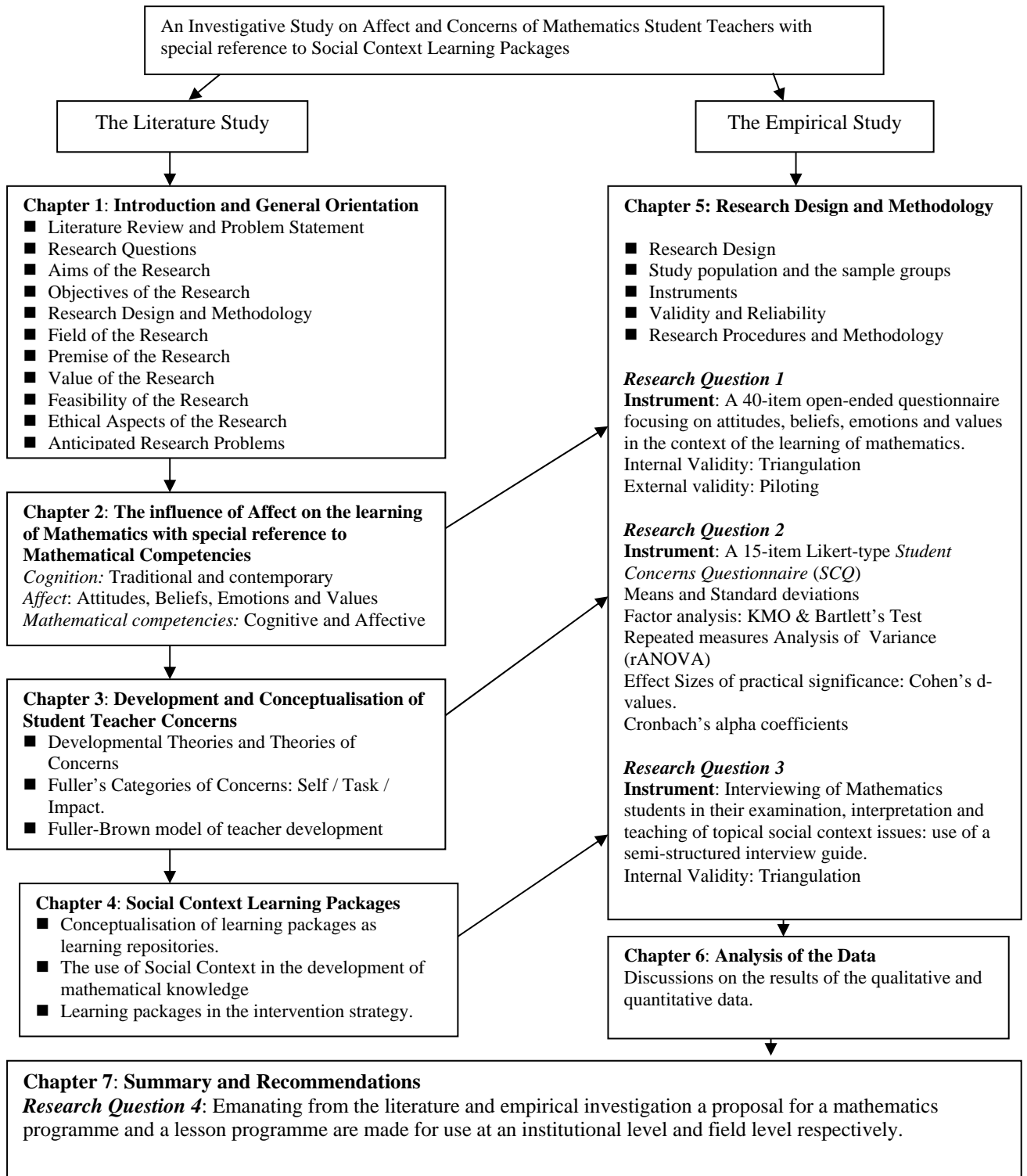


Figure 1.4: An Overview of the Study

1.12 STRUCTURE OF THE THESIS

CHAPTER 1: INTRODUCTION AND GENERAL ORIENTATION

The aim of this chapter was to provide as concise and complete as possible an overview of the problems that were going to be researched. It outlined the preliminary literature review, the aims and objectives of the research and the research design and methodology. The field, premise, value and feasibility of the research were discussed, as well as the anticipated research problems.

CHAPTER 2: THE INFLUENCE OF AFFECT ON THE LEARNING OF MATHEMATICS WITH SPECIAL REFERENCE TO MATHEMATICAL COMPETENCIES

This chapter focused on the role of affect in mathematics education. It acknowledged the dominance of cognitive theories as an overarching domain but sought to explore the influence of affect constructs on the learning of Mathematics and the development of mathematical competencies.

CHAPTER 3: DEVELOPMENT AND CONCEPTUALISATION OF STUDENT TEACHER CONCERNS

This chapter reviewed research undertaken by Fuller and her associates on the conceptualisation of students' concerns and deals with the concerns categories (survival, task and impact). The work of other researchers in this domain was also reported upon.

CHAPTER 4: SOCIAL CONTEXT LEARNING PACKAGES

This chapter emphasised the skilling of students to critically engage with mathematical issues that occur in contemporary real-life situations, as well

as its relation to thoughtful decision-making (bias/non-bias). The nature of reflective dialogue in aiding students to develop their own thoughts and understandings of controversial social context issues in Mathematics was promoted. Social context learning packages used in the intervention strategy were discussed.

CHAPTER 5: RESEARCH DESIGN AND METHODOLOGY

This chapter provided an explication of the research design and methods, together with the research procedures, used for the collection of the data. The process of collecting the data was explained from a qualitative and quantitative mixed-mode platform.

CHAPTER 6: ANALYSIS AND INTERPRETATION OF THE DATA

An analysis of both the qualitative and quantitative data was made in this chapter based on the information gathered during the measurements. Inferences were made from the sets of data. Both numerical and narrative (written and verbal) data produced a corpus of information needed to render credibility and trustworthiness to the study.

CHAPTER 7: SUMMARY AND RECOMMENDATIONS

The final chapter summarised the findings of the study and based on these findings the appropriate recommendations were made. A proposal for the development of a mathematics programme at institutional level (that incorporates the qualitative measurement of affect in the learning of Mathematics) was made. A lesson programme (integral to the proposed mathematics programme) was recommended for Mathematics students in order to track changes in concerns during field practicum sessions.

CHAPTER 2

THE INFLUENCE OF AFFECT ON THE LEARNING OF MATHEMATICS WITH SPECIAL REFERENCE TO MATHEMATICAL COMPETENCIES

2.1 INTRODUCTION

An underlying assumption within the field of mathematics education is that student teachers have to become competent in order to teach learners Mathematics in schools. The question arises as to what kind of knowledge they need as prospective teachers in order to become effective teachers of Mathematics and what kind of knowledge they need to possess as pre-service student teachers in order to learn Mathematics meaningfully. A fundamental question that needs to be addressed is how teacher education can be conceptualised, so that mathematics programmes and activities can be created to assist in the development of mathematical competencies from both a theoretical and didactical perspective. In order to maintain some form of synergy and coherence between theory and practice, student teachers must be given the opportunity to strengthen their own mathematical competencies through reflection and practice. The theoretical constructs of mathematical knowledge are multi-faceted and multi-dimensional and their primary cognition is related to addressing the issue of understanding and comprehending what the nature of Mathematics entails. The nature of Mathematics addresses the essential qualities or characteristics by which Mathematics is recognised and understood. Mathematics by nature is both a pure, theoretical adventure of the mind and a practically applied science. The abstract nature of theoretical Mathematics gave birth even in antiquity to the fundamental dichotomy of Mathematics as an object of study and also as a tool for application (Hassan, 2007:1-2). The didactical constructs of mathematical knowledge are the focus of the teaching and learning functions.

It embodies varying strategies to ensure best didactical practices in the strategic teaching and meaningful learning of Mathematics that ranges from simple knowledge (informal/intuitive) to the more complex (abstract) [also see Kizlik (2012:para.3-4)]. Both theoretical and didactical constructs are traditionally embedded within cognitive frameworks. To put into perspective the influence of affect on the learning of Mathematics, a deeper appreciation and understanding needs to be developed first as to how cognition dominated the arena of knowledge genesis, knowledge construction and knowledge development. Cognitive theories on teaching and learning were the theories that dominated early research on education. Very little or minimal consideration was extended to the possible impact that affect may have on the teaching and learning functions (see McLeod (1992:577)). This chapter acknowledged the dominance of cognitive theories as an overarching influence on education and curriculum models but sought to explore the influence of affect on the learning of Mathematics with special reference to the development of mathematical competencies. A schema for this chapter is outlined in Figure 2.1.

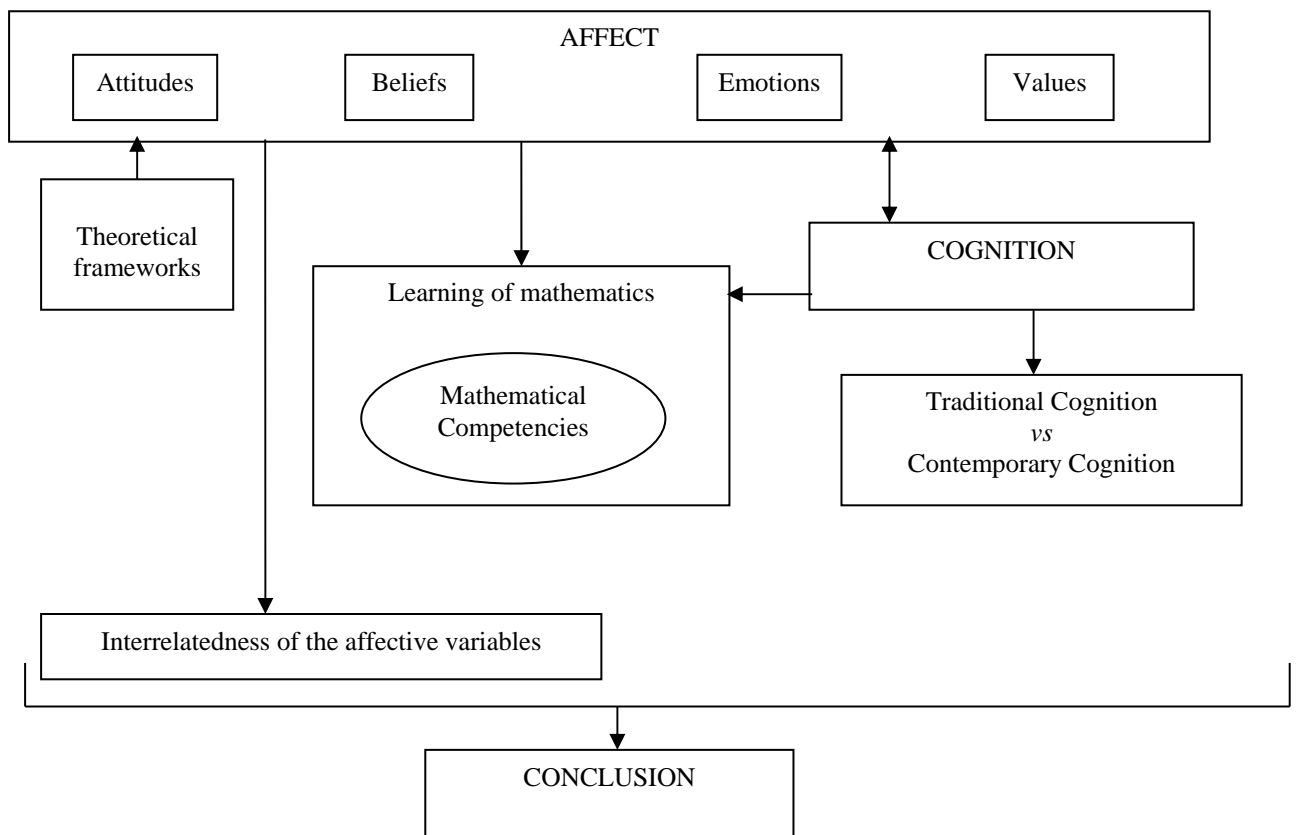


Figure 2.1: Schema for Chapter 2

2.2 COGNITION AND AFFECT: A NEED FOR A PARADIGM SHIFT

In order to fully comprehend the influence of affect on the didactical nature of teaching and learning, an appreciation of the role of cognition needs to be developed, from both traditional and contemporary perspectives. From an education perspective, cognitive constructs provide the coherent theoretical and methodological framework for the examination of the teaching and learning processes. Behind these constructs however, lie tacit or explicit belief systems based on a varied spectrum of epistemologies. The epistemological view of traditional mathematics education is based on the premise that the correct use of efficient mathematical rules and algorithms, attained through drill and practice (memorisation, rule learning and training in routine problem-solving), will allow learners to use knowledge of concept and procedure appropriately. Based on this mastery, more complex mathematical procedures can then be introduced later on. Such low-order approaches found in the traditional model for teaching are product-directed and teacher-centred and serves best the learning of basic knowledge, facts and skills and may not be appropriate enough to prepare learners (as well as student teachers) for the real-life situations beyond the classroom. According to Nieuwoudt (2000:18-19), research has already revealed the limiting features of the traditional approach, *inter alia*:

- Mathematics is seen as a static and bounded discipline to be taught and studied within the boundaries of the discipline.
- The recorded knowledge of Mathematics is seen as the total body of mathematical knowledge.
- The role of the teacher is seen to be mainly managerial and procedural in nature.
- Routine rather than creative activities are emphasised in classes.
- Mathematical learning proceeds algorithmically rather than meaningfully.

The primary assumption underlying the traditional cognition toward teaching and learning is that meaning is inherent in the words and actions of the teacher (attributes of a behaviouristic paradigm).

However, this assumption is challenged by a variation of new (contemporary) approaches to teaching and learning Mathematics that are based on the premise that learners have a mathematical reality of their own. Cobb (1988:89) states that “the teacher’s role is not merely to convey information about Mathematics to learners but rather to facilitate profound cognitive restructuring and conceptual reorganisations”. This view is supported by Von Glaserfeld (1989:182) who avers “that cognition should be adaptive and should serve the organisation of the experiential world”. In South Africa, the introduction of education transformation (post-1994) has seen the pendulum swinging to the implementation of teaching approaches directed at the development of the learning functions that may help learners cope with life outside of school. To this end, the process-directed and learner-centred approaches have come to be used in mathematics classrooms through a transformation to a learner-centred/activity-based curriculum. The epistemology of the “transformed curriculum” coincides with the reform views of Goldin (2002b:200) who posits its attributes as learners “engaging in real-life, contextualised and open-ended problem-solving, in which high-order mathematical reasoning processes are central and universally accepted”.

Teachers using this “new approach” should now encourage learners to solve problems cooperatively in groups as well as individually, and allow them to invent, compare and discuss mathematical techniques as they construct their own viable mathematical meanings. The sequentially developed constructs ranging from the “old” to the “new” approaches elaborated on in this chapter (see Table 2.1) are based on the politico-ideological poles (within a South African context) embedded in a temporal framework ranging from pre-1994 to post-1994. More specifically, according to Higgs (1994:1), South African education during the apartheid era focused primarily on education as a process of socialisation, immersing individuals in ideological and political concerns. This deflected attention from more universal human concerns that were foundational in the restructuring of a more legitimate education system for a post-apartheid South Africa. (The researcher contends that even though there is a continuous political transformation process underway in South Africa, the empowerment of learners through an environment conducive to a learner-centred/activity-based approach has not yet revealed any discernible evidence that has aided the restoration of a culture of learning. The notion of educational redress seems to be more political and concomitant with political entitlement and the achievement of political goals rather than with educational outcomes.)

The paradigmatic shift in education transformation does not necessarily imply a complete change in the aetiology of constructed knowledge, since both approaches (old and new) can find common genesis in cognitive epistemologies. For instance, in order to construct meaningful mathematical knowledge (within both approaches), one has to interrogate the foundational nature of Mathematics. A large and varied body of thought purports to define Mathematics as abstract computation involving aspects of problem-solving. But upon examination, opinions range from the earliest views on mathematical structures (Pythagorean number theory, Euclidean Geometry, Boolean Algebra, *etc.*) (see Thom and Thom (1988:132-133)) to the most recent schools of mathematical philosophy, that now encompasses social interaction and social context (the mathematising and contextualising of situations/topical events) outside the sphere of traditional and applied Mathematics.

The shift to the cognitive-focused and outcomes-based curriculum appears to have been problematic for more than a decade. Proposals for the revisions of the curricula were made, *inter alia*, by *The Review Committee on Curriculum 2005* (DoE, 2000:18-21), who identified several shortcomings within the then curriculum (Curriculum 2005). This could be viewed as an acknowledgement of the difficulties surrounding the complete functional implementation of a learner-centred and activity-based model within the South African education context. However, reluctance to implement whole-scale restructuring of the national curriculum could be ascribed to the embedding of such an education policy within a politico-ideology, yet there are tacit acknowledgements of the problems *vis-à-vis* numerous curriculum revisions. It was the *Report of the Task Team for the Review of the Implementation of the National Curriculum Statement* (DoE, 2009:6) that compelled government to bring about curriculum reform to the so-called transformative OBE curriculum (Evans, 2010:2), through the introduction and phase implementation of the CAPS in 2011. The CAPS, like previous curricula, acknowledged the influences that affect constructs, such as attitudes and values, have on the teaching and learning processes. However, not enough emphasis (if any) is placed on incorporating measurable indicators to monitor these affect constructs within the curricula, as is done for the cognitive constructs and their associated variables (in terms of outcomes, general and specific aims and objectives). The CAPS (DBE, 2011b:4-7) has repackaged the existing curriculum into:

- the general aims of the South African curriculum;
- the specific aims of each subject;
- delineated topics to be covered per term; and
- the required number and type of assessments per term.

In this way, outcomes are absorbed into more accessible aims, and content and assessment requirements are more clearly spelt out. Topics and assessments to be covered per term are being aligned to available time allocations per subject (DBE, 2011b:6). The implementation phase for the CAPS started in the Foundation Phase in 2011. Piece-by-piece curriculum revisions seem to be the order of the day as South Africa strives to modify and adapt its National Curriculum to the educational demands of its citizens, as well as to a competitive knowledge-based global society. A complete overhaul of the National Curriculum may not be advisable from a political perspective, but from a socio-economic perspective the need for improved achievement and skilled performances (set against international academic achievement and performance benchmarks) may one day become an overriding consideration for looking at other education models best suited to attain and establish a dynamic culture of learning. In addition to the call for *back to basics*, the restoration of a culture of learning appears to be one of the greatest challenges that teachers and learners will have to face sooner rather than later (Badenhorst, 1998:408). Furthermore, a recurring concern that needs to be addressed is the nature of flexibility within curriculum design and its interpretation by teachers. If curriculum revisions are to bring about the necessary changes called for (by the 2000 and 2009 Review Committees), the restructuring of the curricula of learning areas (which will now revert to being called subjects) will inevitably have to receive more attention in the foreseeable future, so too the influence of affect on teaching and learning as measurable indicators of performance and achievement.

2.3 AFFECT AND MATHEMATICS EDUCATION

Traditionally research on affect in mathematics education was minimal or even avoided, since learners were rather regarded as mechanistic and the influence of the behaviouristic approach dominated early research in education.

In the recent past the growth of developmental psychology and the rising influence of cognitive psychology have refocused the attention of researchers on the role of affect. McLeod (1992:578), a pioneer in the field of research on affect, describes three constructs of affect: *beliefs*, *attitudes* and *emotions*. He declares that *affect* be used as a more general term and that other terms such as beliefs, attitudes and emotions be considered as more specific descriptors or variables of subsets of the affective domain (p. 576). McLeod (1992:575) states that affective issues play a central role in Mathematics and if learners are going to become competent learners of Mathematics, their affective responses to Mathematics are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low-order mathematical skills. Past research in the learning of Mathematics has traditionally been studied from the perspective of the cognitive domain (Liljedahl, 2005:221). However, performances and achievements can no longer be the exclusivity of the cognitive domain but should be viewed concomitantly with affective constructs which can be seen as indicative of learning outcomes or predictors of future success. The mathematical competencies of learners (as well as students) and the mathematical abilities of teachers can be invariably linked to some influences from the affective domain (see paragraphs 2.6 and 2.8). Schiefele and Csikszentmihalyi (1995:164) state that the impact of affective constructs is often underestimated because it tends to have indirect rather than direct effects on achievement. To attain optimal performance in the teaching and learning of Mathematics, researchers in mathematics education need to acknowledge the role and impact of affective issues and integrate them into studies of cognition. This view is supported by McLeod (1994:642) who recommends a more integrated approach to research on affect and cognition. According to McLeod (1992:577), attempts at this integration can be traced back to research conducted in 1962 and 1967.

Within the mathematics domain, much can be said about *attitudes towards mathematics*, *belief about mathematics*, *emotional reactions towards mathematics* and *values about mathematics*. In this study, these are the variables (sub-categories) of affect constructs that are discussed in more detail in this chapter. Early cognitive theories contributed greatly to the understanding of how mathematical knowledge is constructed and interpreted but the increasing focus on the role of *affect* in mathematics education has necessitated the need to acknowledge this domain too in the internalisation of mathematical knowledge through its acquisition and development.

There is no doubt that the cognitive domain has been foundational and has bi-directional influences with the affective domain. Nevertheless, McLeod (1992:590) suggests that a major difficulty in the research on affect has been that it is not grounded in a strong theoretical framework and that there is little connection with the theoretical foundations of cognitive research in mathematics education. However, Hannula, Evans, Philippou and Zan (2004:108-109) states that “partly because of the different epistemological perspectives of researchers, there is considerable diversity in the theoretical frameworks used in the conceptualisation of affect in mathematics education”. This can partly be ascribed to the dominance most researchers place on the cognitive outcomes in most curricula, courses and programmes. The modern approaches of cognitive theories and the influence of affective constructs have culminated in the reconceptualisation of what mathematics education entails. For teachers, students and learners, questions concerning the nature of Mathematics are more likely to arise in their attempts to understand and engage in mathematical thinking and activities albeit within their own meta-cognitive and meta-affect processes. Goldin (2002a: 62) proposed the construct of *meta-affect* to refer to “affect about affect, affect about and within cognition that may again be about affect, the monitoring of affect, and affect itself as monitoring”. Affect can now rightfully take its place as a determinant in our efforts to understand its influences on the learning of Mathematics. It is the researcher’s contention that the division of the affective domain into beliefs, attitudes, emotions and values constructs seems appropriate for the interests and views of researchers in their pursuit of how mathematical knowledge can be internalised and understood from within the affective domain.

The mathematics curricula for South Africa are not neutral and encourages classroom pedagogy through processes involving social interaction (peer learning) as part of classroom activities. Our mathematics curricula have been informed and shaped by historical and cultural antecedents and has placed (a portion of) mathematics cognition within a social context framework (consider the mathematising of varied contexts and the introduction of the Mathematical Literacy learning area) that has allowed learners to bring their own experiences, preferences and learning styles to the learning process. The classroom has now become part of the wider community, allowing the acquisition of knowledge to be influenced not only by cognition but also by cultural practices and social norms. Social context within the learning environment is an essential part of *experiencing* cognition and affect and can contribute fundamentally to individual knowledge construction (see Donald, Lazarus &

Lolwana, 2002:239). Underscoring the presentation of statements in this sub-paragraph is the notion of social cognitive theories. A social cognitive theory is a contextual view because it posits that behaviour represents an interaction of the individual with the environment that forms part of the social context (Pintrich & Schunk, 2002:188). It is within the classroom environment that formal or mainstream education is contextualised for learners, students and teachers. According to Franke, Kazemi and Battey (2007:225), mathematics classrooms reflect “particular kinds of social contexts where the structures of activity within them afford and constrain what is learned, how it is learned, and which learners learn it”. From a teacher’s perspective, the “tools” of cognition such as symbolism, language, notation, *etc.*, are characterised by how mathematically competent learners and students are at using and understanding these tools for knowledge acquisition and developing their own strategies for problem-solving. With regard to the teacher’s cognition, mathematical content knowledge and pedagogical content knowledge are of utmost importance in ensuring the strategic and effective teaching of Mathematics. This begs the question as to how the “tools” of affect would influence the mathematical competencies of learners and students. In the affective domain, the attitudes, emotions, beliefs and values of learners and students have the ability to influence their respective achievements and performances in the learning of Mathematics.

2.4 THE SOCIAL CONTEXT OF COGNITION AND AFFECT

Figure 2.2 depicts how the confluences of the cognitive domain with the affective domain (and *vice versa*) are interactional within a social context framework. The model proposed in the figure was adapted and modified from a model entitled *An overall framework for affective constructs within mathematics education research* (see Hannula, Pantziara, Waege & Schlöglmann, 2009:29). The model is used in this study to best provide a helpful contextual framework for understanding cognition and affect and their influences on the learning of Mathematics. A sub-domain of this model (intersecting area of Learning of Mathematics with the Affective set) can be interpreted in terms of understanding one of the variables of this study, namely *the influence of affect on the learning of Mathematics* (with particular reference to the development of mathematical competencies). In the model, social context provides a universal domain for the sub-setting of classroom context.

The social context domain is regarded as an overarching description that encompasses a person's position within a social system (Donald, Lazarus & Lolwana, 2002:3). This allows for a range of social issues to be addressed that affects the learning processes and affirms that the education process is not seen as being isolated from community and family interests but being part of the communities of practice (see Social Theory of Learning, paragraph 2.8). While Piaget viewed (traditional) cognitive development as taking place from the *inside out*, Vygotsky was more concerned with how it happens from the *outside in* (Donald, Lazarus & Lolwana, 2002:69-70). At the centre of Vygotsky's theory is the notion that (contemporary) cognitive development takes place through social interactions and relationships (social context).

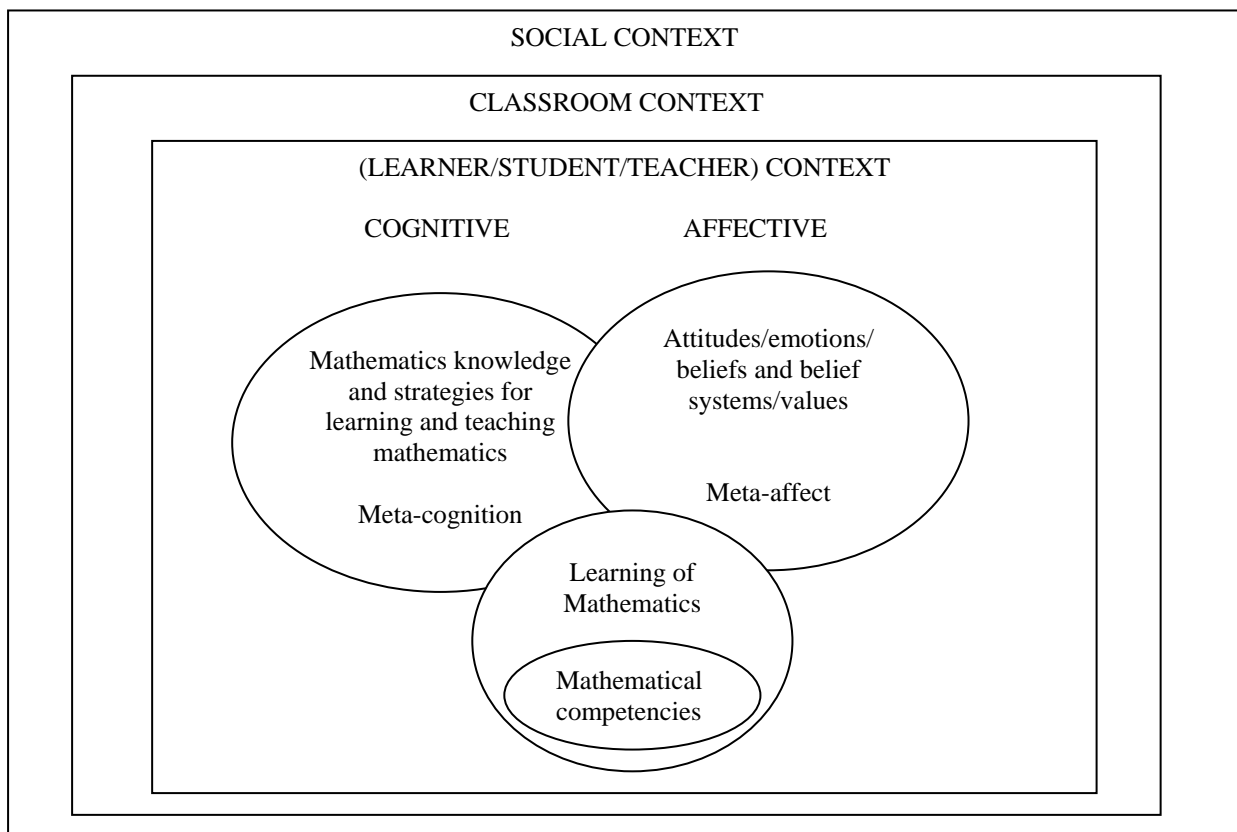


Figure 2.2: Learning of Mathematics with a Social Context Framework

(Figure 2.2 adapted from Hannula, *et al.*, 2009:29).

The *construction of shared meaning* happens through the interactions that children have with their peers, parents and others within their social context (Donald, *et al.*, 2002:70). The significance of social context within the sphere of education is that learning takes place within the *life-world* and the *life-experience* of the learners and students and that the notion of learners and students living and making decisions under varying social, cultural, political,

economic and environmental conditions are the realities of the cognitive constructs of knowledge genesis, knowledge construction and knowledge development. Meanings are the constructs that cannot be divorced from the social context, so too is the centrality of social context to cognition and affect. The process of individual cognitive development is seen as taking place through the same process as social interaction (Donald, *et al.*, 2002:69-70). Analogously one can claim that the situatedness of social context is constitutive to learners' affect development (see Figure 2.2). A further exposition of affect in mathematics education and its influence on the learning processes is presented in paragraph 2.8. The inclusion of mathematical competency in the model (as a subset of the Learning of Mathematics domain in Figure 2.2) is not only to show the influences of cognition and affect on the development of learners' mathematical competencies, but also to acknowledge their (mathematical competencies) meaning as an ability to understand, judge, do and use Mathematics in a variety of classroom contexts and social contexts in which Mathematics plays or can play a role.

2.5 MATHEMATICAL COMPETENCIES

The ability of being competent does not happen as an all-or-nothing phenomenon nor does it happen only through experience or success. Some of the elements of having to struggle and persevere are inevitable and that is what engenders a sense of competence. Mathematical competency can be viewed as the ability to do Mathematics well, as measured against acquired experience or training (Niss, 2002:6-7). If mathematical competency is to grow and develop, diverse opportunities for active mathematical interaction and engagement need to be fostered and nurtured.

2.5.1 Domain of Mathematical Competencies

Snyders (2008:235) posits that to be successful in any field of study in the broad area of Mathematics, a number of skills and competencies need to be developed within the field of teaching and learning and identifies some of them within:

- Problem-solving: the ability to analyse a situation and make decisions regarding possible techniques that can be used to solve the problem.
- Language skills: good textual analysis skill is a critical competency to assist Mathematics learners to make the link between the symbolic notations and real-world problems.
- Creativity: creative thinking is necessary when confronted with non-routined mathematics problem situations.

Niss (2002:7-9), appointed as a director of a Danish project to create a platform for in-depth reform of Danish mathematics education, states that “to master Mathematics means to possess mathematical competence”. He identifies eight competencies in Mathematics which can be categorised within two groups:

First Group: *To ask and answer questions in and with Mathematics* (p.7-8)

- Thinking mathematically: mastering mathematical modes of thought.
- Posing and solving mathematical problems: pure or applied, open or closed problems.
- Modelling mathematics: analysing and building models.
- Reasoning mathematically: assessing chains of arguments, transforming heuristic arguments to valid proofs.

Second Group: *The ability to deal with and manage mathematical language and tools* (p.8-9)

- Representing mathematical entities: understanding and utilising different sorts of representations of mathematical objects, phenomena or situations – choosing and switching between representations.
- Handling mathematical symbols and formalisms: decoding and interpreting symbolic and formal mathematics language – understanding the nature and rules of formal mathematical systems (both syntax and semantics).
- Communication in, with and about Mathematics: understanding written, visual or oral text having mathematical content.
- Making use of aids and tools: knowing the existence and properties of various tools and aids for mathematical activity, and their range and limitations.

There are other categories of competencies within the teaching and learning of Mathematics. Features of mathematical competency within traditional cognition are easily identifiable as done in the preceding texts of this chapter. The obvious questions arise as to how these mathematical competency features can be interpreted or even translated within contemporary cognitive theories, especially from a social context perspective (see paragraph 2.7.3).

2.5.2 Traditional Cognition and Mathematical Competencies

Mwamwenda (2004:129) views competence as “what a person is capable of doing cognitively” and differentiates between competence and performance by stating that “performance entails the actual process of carrying out what a person is capable of doing cognitively”. However, performance does not necessarily imply competence and *vice versa*. In Mathematics, it is possible for learners and students to possess the necessary mathematical competence and yet may not be in the position to translate it into a required observable behaviour (performance). It has been noted by this researcher that some learners who are competent in Mathematics during classroom interactions, lack the performance ability to teach during field practicum, and the opposite scenario has also been detected.

One of the major stumbling blocks for student teachers during field practicum is performance anxiety that can be linked to their perceptions of their behaviour during classroom teaching (as part of their field training). Other factors contributing to this situation may be cognitive in nature, for example, language and comprehension limitations, unfamiliar contextualisations, *etc.* (Murray, 2003:40). Some factors may even be affective in nature, for instance, negative attitudes towards mathematics, mathematical anxiety, *etc.* To determine whether mathematical competency exists among learners and students, the completion of cognitive mathematical tasks is but one indicator (Niss, 2002:10).

The response time for completion of tasks can be interpreted as evidence of the degree of mathematical competency possessed by the learner (Note: This is not the ultimate benchmark for detecting mathematical competence among learners and students). Within traditional cognition, criteria associated with mathematical competency are embedded primarily within the two Piagetian stages of concrete operations and formal operations.

Mathematical competency within the stage of concrete operations involves the abilities to use manipulatives or concrete objects or learning media to perform mathematical tasks (informal/practical Mathematics) or to do elementary Mathematics through rote learning or memorisation (simple information acquisition). For mathematical competency within the stage of formal operations, the focus shifts more to application, synthesis, analysis and evaluation of mathematical tasks (formal Mathematics). Traditional cognitive theories (aligned more to the Piagetian structures of human development) are very much behaviourist in undertone.

Contemporary cognitive theories are becoming less behaviourist and more social context in nature (aligned more to the Vygotskian' school of thinking). Although Piaget and Vygotsky appear to present opposite views on cognitive development they should not be interpreted as contradictory but rather as presenting different and non-diametrical perspectives (Donald, *et al.*, 2002:70). [Note: Apart from Piaget and Vygotsky, other researchers have made significant contributions to our understanding of development and cognition especially in the fields of cognitive development, behaviourism, on psychodynamic perspectives, on the ecological perspectives, on the transactional perspectives, on the perspectives of vulnerability and resilience and on psychosocial development.]

2.5.3 Contemporary Cognition and Mathematical Competencies

Individual knowledge construction can also be influenced by contemporary cognitive theories, in particular, the socio-constructivist approach to the learning of Mathematics. Knowledge is not fixed and given. Rather, it is shaped, constructed and re-constructed in different social contexts and at different times (Donald, *et al.*, 2002:104). What are the mathematical competencies that learners and students need to possess (within the so-called contemporary cognitive parameters) in order for them to utilise the tools of the new approaches to learning? In order to answer this question, there is no doubt that learners and students need to possess meta-cognitive abilities to develop mathematical competencies when required to construct their own knowledge. This entails an awareness of what goes on in their minds, an understanding about their own thinking, planning and remembering.

In constructivist terms, meta-cognition is pivotal in the higher-order context of understanding and thinking about one's own cognitive abilities, as well as for learning to become meaningful. From a meta-cognitive and socio-constructivist perspective, the following (*inter alia*) mathematical competencies need to be developed for learning to become meaningful (see Table 2.1, Curriculum Component: Learners – Adapted from Study Guides LEON 612 and LEON 613 (2007). North-West University: Potchefstroom.):

- The abilities of learners, when presented with mathematical problems, to use their own or alternative methods of problem-solving and not the routine procedures or drilled responses encouraged by the traditional curricula.
- The abilities to construct methods (on their own or through guided-activity) for solving problems.
- The abilities to discuss and explain and if necessary, justify interpretations and solutions to other learners/teacher.
- The abilities to pose questions, classify data, look for patterns, infer, analyse and validate the results of self-constructed solutions.

2.5.4 Traditional Cognition versus Contemporary Cognition

The combined traditional and contemporary mode of teaching (see Appendix G) proposed by this study encourages the development of those mathematical competencies inherent in both traditional and contemporary cognitive approaches. The lesson programme is embedded within the ambit of traditional pedagogy (focusing on conceptual and procedural teaching and learning) and a learner-centred/activity-based methodology (focusing on task and contextual teaching). The rationale for the lesson design is to acknowledge the need to retain aspects of the learner-centred/activity-based approach and the need to return *back to basics* as called for by the *Schooling 2025* initiative. The researcher alludes that the adoption of this mathematics lesson design (as part of a proposed mathematics programme – see *Research Question 4*) can provide some form of structure to mathematics lesson phase progression and will come a long way from previous lesson design formats used. More so, the attributes of this design format may inform this study as to the particular concerns that student teachers may experience when using this approach.

The paradigmatic shift in cognition from the traditional cognitive approach to a contemporary cognitive approach is highlighted in the curriculum components as tabulated in Table 2.1. To understand the development of mathematical knowledge within these two cognitive approaches at any given time, it is necessary to take into consideration not only the formal structures inherent in this discipline (Mathematics) but also the orientation epistemologies embedded in its evolution over time. The preceding statement, however, negates the traditional cognitive view of Mathematics as a static and bounded discipline. Mathematics is not a discreet discipline unrelated to other varieties of the knowledge systems – rather it is a social creation which changes with time and circumstances.

In contemporary Mathematics, there is a shift from discovering reality to understanding the context of a person's perception of his/her reality. From an ontic perspective, social context mathematics is but one facet in the development and construction of mathematical knowledge (see paragraph 4.2.1). Notwithstanding the tremendous amount of research undertaken by cognitive theorists, research on affect and the influence of affect on the learning of Mathematics is minimal or often neglected. The curriculum components of both approaches show no discernible evidence of the influence of affect on the teaching and learning functions. Gerretson and Golson (2005:139) and Stone and Friedman (2002:199) ascribe the lack of learners' affective development to the seeming inability or unwillingness to specify the affective outcomes of these curricula, courses and programmes. *Affective outcomes* may be regarded as expressions of statements involving attitudes, beliefs, emotions and values.

Table 2.1: Differences between the Traditional Cognitive Curriculum and the Learner-centred /Activity-based Cognitive Curriculum

CURRICULUM COMPONENTS	TRADITIONAL COGNITIVE CURRICULUM (OLD APPROACH)	LEARNER-CENTRED/ACTIVITY BASED COGNITIVE CURRICULUM (NEW/TRANSFORMATIVE APPROACH)
Aims and objectives	Refers to the intentions of the syllabus	Refers to the outcomes (results) that learners should attain/purposeful outcomes
	Refers to long- and short-term goals	Learning outcomes not within rigid time frames
	Aims of the curriculum focuses on the attainment of specific knowledge	Exit outcomes of curriculum focus on learning content (knowledge), skills and attitudes
	Objectives as statements of short-term intent	Outcomes as statements of long-term intent
	Aims/objectives as statement of teacher intent	Outcomes as statements of learner achievement
Learners	Passive receiver of knowledge	Active role of learner
	Focus on independent learning – contest learning and competition	Accommodates co-operative, peer-peer learning.
	Relies on information from teacher in terms of right answers	Encourage to construct knowledge for themselves
	Focus on learners’ level of cognitive development	Focus on cognitive, interpretive, critical, analytical skills, etc.
	Focus on moulding of learners - regarded as empty vessels	Focus on addressing the needs of the learners
Teacher	Teaching is the central focus in class	Learning is the central focus of class
	Uses traditional teaching methodologies (behaviourist / process-product teaching)	Use innovative teaching strategies (constructivist, ontological-contextual teaching)
	Regarded as the transmitter of knowledge	Additional roles as a facilitator / mentor / researcher, etc.
Specific society	Minimal influence on curriculum design	Significant variable in curriculum design
Didactic environment	Characterised mostly by teacher-learner-content	Consists of more than the three variables
Learning Content	Subject matter focus on body of knowledge	Learning content focus not just on knowledge but on knowing - meaningful learning
	Little attention to context or process of learning	Real-life context/focus on process of learning
	Limited use of other/alternative resources	Wide variety of sources of information
	Subject matter developed around textbook	Learning content developed around wide variety of content-contextual resources
	Compartmentalised in content	Cross-curricula approach to outcomes
Curriculum	Teaching methods and strategies were meant to be the only guidelines for teachers	Wide variety of teaching strategies and forms of assessment
	Rigid syllabi prescribing teaching and learning	Flexible curriculum prescribing teaching-learning in context of learner characteristics and community needs
	Teacher –centred	Learner-centred and activity-based
	Composed on separate structures (school/syllabi, etc.)	Formed on collaborative structures (for curriculum planning, instruction, learning)
Evaluation	Summative evaluation	Continuous assessment and formative in nature
	Norm-referenced evaluation	Criterion-referenced assessment
	Examinations orientated	Encompass other forms and types of assessments

Adapted from Study Guides LEON 612 and LEON 613 (2007). North-West University: Potchefstroom.

Even though both the traditional and contemporary cognitive curricula are differentiated along the lines of the curriculum components, its generic basis has provided an ideal framework to be able to assess mathematical competencies within the affective domain.

2.6 AFFECT AND MATHEMATICAL COMPETENCIES

The discussions in paragraphs 2.5.2 and 2.5.3 centred on cognition and mathematical competencies, and a few competencies, *inter alia*, were identified albeit from a traditional or contemporary perspective. The defining statement about mathematical competencies is that it refers to the abilities of learners and students to perform particular mathematical tasks, use particular algorithms or process information in a particular way and to construct or be guided to particular representations of solutions to these tasks. These mathematical competencies are embedded within the cognitive domain, hence the reference to cognitive competencies. Analogously, affective competencies refer to the abilities of individuals to make effective use of affect during mathematical activities (Goldin, 2004:112). Affective competencies and cognitive competencies cannot be viewed as synonymous – the ability to solve or construct a solution to a mathematical problem using observable routine or non-routine algorithmic procedures (cognitive) is completely disjointed from the affective competency in trying to avoid shame in failing to solve or construct solutions to a mathematical problem. The affect constructs and their associated variables are used to better interpret learners' mathematical behaviours than what a purely cognitive approach is able to explain. According to Philippou and Zan (2004:132), the need to interpret instead of explaining is linked to the transition from a normative (positivist) paradigm to an interpretative one, a necessity when taking into account the complexity of human behaviour and the intentional acts of human beings.

According to the interpretative paradigm, researchers search for an understanding of learners' intentional actions in the context of mathematical activities and not for explaining behaviour based on the cause-effect rule (Gay, Mills & Airasian, 2009:12). In answering the question posed in paragraph 2.3 about how the “tools” of affect would influence the mathematical competencies of learners and students, one has to acknowledge that the affective domain has the power to transform its constructs towards the learning of Mathematics in a positive

manner that makes these instances an indispensable resource for fostering the development of mathematical competencies. Liljedahl (2005:219) states that a transformative effect (through an AHA! experience) on “resistance students” affective domain has had a positive influence on their mathematical competencies. Positive experiences and stability are essential in the affective domain because of the influences they can exert on the learning of Mathematics, which can invariably determine how competent a learner can view himself/herself in Mathematics. Learners with strong self-concept, high confidence and positive motivation have the potential of becoming highly competent Mathematics learners.

In the studies on mathematics cognition, the focus of mathematical competencies is on abilities and capabilities while within the affective domain, competencies in Mathematics are more than the abilities to perform observable tasks. Rather, the focus of the affective competencies lies in the direction (positive or negative), the degree (positive or negative) and the levels of intensities (strong or weak) of these affect constructs (or their variables) that redefine mathematical competencies within the affective domain. Some mathematical competencies within the affective domain (affective competencies) are listed below (adapted from Goldin, 2004:212-213):

- To be able to act on *curiosity* when doing mathematical tasks, assignments or projects.
- The ability to take *frustration* as a signal to alter a mathematical strategy.
- To be able to develop *integrity* and *truthfulness* in Mathematics.
- The ability to be *committed* during mathematical activities.
- To be able to develop mathematical self-identity – the *sense of self* in relation to Mathematics.
- To be able to address feelings of *bewilderment* when confronted with non-routine mathematics problems.
- The ability to experience *encouragement* as progress occurs in Mathematics.
- To be able to experience *elation* when new insight occurs in mathematical tasks.
- To be able to experience *satisfaction* when solving a difficult problem or understanding a new mathematical concept.
- The ability to avoid *shame* that may signify failure to do mathematical tasks.

The affective competencies listed in this paragraph can be associated in some form or other with the sub-domains within the tetrahedron model for affect that is defined by constructs of attitudes, beliefs, emotions and values. Each construct has the potential of influencing the learning of Mathematics in different ways.

2.7 THEORETICAL FRAMEWORKS FOR AFFECT

The placement of affective constructs within theoretical frameworks still appears problematic. According to Hannula, *et al.* (2004:107), partly because of the diversity in research areas and epistemology, “there is considerable diversity in the theoretical frameworks used in the conceptualization of affect in mathematics education”. This study reviews, *inter alia*, some of the theoretical frameworks used to study affect in mathematics education.

2.7.1 Affect as a System of Representation (1st theoretical framework)

Perspective of Gerald A. Goldin: He interprets affect as a representational system - parallel to cognitive systems - that encodes important information regarding problem-solving.

Synopsis [Source acknowledgement: Hannula, *et al.* (2004:109-114).]

To consider affect as having a basic *representational* function seems to be a less than usual perspective in psychology. More often, emotions are described merely as accompanying cognition or occurring in parallel with cognitive activity. Usually they are regarded as consequences of cognition, and often as having immediate consequences for cognition, either facilitating or impeding cognitive activity. Going beyond these evidential features, affect can be regarded much more fundamentally as one of several internal, mutually-interacting *systems of representation* within an individual human being. That is, the affective system functions *symbolically* so as to encode essential information.

For instance, our emotional feelings and the complex structures involving them have *meanings*, even when we may not be consciously aware of those meanings or able to articulate them (Hannula, *et al.*, 2004:109). Among the kinds of information commonly encoded affectively are:

- Information descriptive of the external physical and social environment in relation to the individual.
- Information regarding the individual's own cognitive and affective configurations.
- Information about other peoples' cognitive and affective configurations.
- Information about social and cultural expectations in relation to the individual.

In doing Mathematics, the affective system encodes information relevant to mathematical problems and especially relevant to the person in relation to the mathematical activity. For instance, the feeling of *bewilderment* in approaching a problem in Mathematics may simultaneously suggest that certain standard problem interpretations or problem-solving strategies do not work. This can be related to the non-routine nature of the problem, the person's lack of specific knowledge or lack of mathematical competencies to construct possible solution scenarios using his/her own methods or through guided assistance. Cognitive representational systems function partly but of major importance is the evoking of affect and the information it encodes. This applies specifically to the internal verbal/syntactic systems, imagistic systems, formal notational systems and strategic/heuristic systems of representation in formulating a model for mathematical problem-solving competency. In short, affective representation is not auxiliary to cognition: it is centrally intertwined with it (Hannula, *et al.*, 2004:110).

2.7.2 Affect in the Functioning of Self-system Processes (2nd theoretical framework)

Perspective of Marja-Liisa Malmivuori: Uses self-regularity constructs for the conceptualisation of affect.

Synopsis: [Source acknowledgement: Hannula, *et al.* (2004:114-118).]

The theoretical construct such as self-regulation affords the opportunity to consider cognition as more closely linked to affect and behaviour in learning and in education. Self-regulation can relate to the conscious monitoring, control, assessment and judgment of states of arousal or responses. The role of self-regulatory aspects of affective responses in social, contextual and situational environments is emphasised. More generally, this view connects these aspects closely to the functioning, qualities and development of learners' self-systems and self-system processes in respect to the learning of Mathematics. Self-regulation processes represent the central combining feature of self-system processes with affect. The qualities and functioning of significant self-system processes ultimately determine the power and role of affect in learners' personal learning or performance processes in mathematical situations. The perspective applies recent cognitive, socio-cognitive, constructivist, as well as phenomenological views of learning and links affect strongly, naturally and in a dynamic way to cognition. Learners' affective responses in social contexts and situations can be linked to their experiences of self-esteem, self-worth and/or their personal control with respect to the learning of Mathematics (Hannula, *et al.*, 2004:114).

The significant relationship between the self and affect is acknowledged in the education research domain where it appears in the close-measured relationship between learners' self-concept, self-esteem, self-confidence or self-efficacy and their responses to aspects of learning. The influence of important affective responses is seen to vary along with the qualities and functioning of personal self-systems in mathematical situations. In this, a basic qualitative distinction is made between learners' *fully functioning self-system processes* and personally powerful learning or doing of Mathematics and, in turn, their *defectively operating self-system processes* and learning with self-defending, habitual or retaining and externally directed performance behaviours, often filled with negative affect (Hannula, *et al.*, 2004:118). Examination of the functioning of significant self-system processes in mathematical situations offers better opportunities for understanding not only the importance of learners' self-identity or self-referential information (Goldin, Op't Eynde) but also their personal involvement and self-regulatory features with Mathematics. The attributes of the self-system processes in affect are foundational to the proposition made by the researcher in

defining the category *values about self* within the variable *values about mathematics* of the affect construct of *values* (see Table 2.4).

2.7.3 A Socio-constructivist Perspective on the Study of Affect in Mathematics Education (3rd theoretical framework)

Perspective of Peter Op't Eynde: Views affect as being primarily grounded in and defined by social context.

Synopsis: [Source acknowledgement: Hannula, *et al.* (2004:118-122).]

From a socio-constructivist perspective, learning is viewed as a fundamental social activity. Learning is getting acquainted with the language, rules and practices that govern the activities in a certain community, in our case the mathematics education community. By engaging in the practices of this community, people discover meaning which becomes jointly constructed in the sense that it is neither handed down ready-made nor constructed by individuals on their own. Well-established meanings might be implied in practices characterising a specific community for many years, but it is through engaging in such a practice anew that the individual experiences meaning and re-negotiates the currently accepted meanings. Learning focuses on engagement that maintains the person's interpersonal relations and identity in communities in which the person participates. In this way, learners' learning in the classroom is characterised by an actualisation of their identity through the interactions with the teacher, the books, the peers with which they engage (Hannula, *et al.*, 2004:119). On one hand, these interactions are determined by the class and school context they are situated in and as such the social context is constitutive for learners' identities (see Figure 2.2). On the other hand, learners bring with them to the classroom the experiences of numerous other practices in other communities in which they have participated or are participating (see Social Theory of Learning, paragraph 2.8). This wide spectrum of past experiences determines the specific way learners find themselves in the class context and its practices, in discovering meaning, and in re-negotiating or constructing new meanings by their engagement in the class activities.

The way learners engage in classroom activities is a function of the interplay between their identity and the specific classroom context. Their motivation to participate in a specific way in certain classroom activities is grounded in the way they find themselves in that context. Taking into account the embedding of learners' knowledge, as well as beliefs in the social context, the interpretation and appraisal processes that ground learners' emotions in the classroom (*e.g.*, anger, fear, *etc.*) are fundamentally constituted by the socio-historical context in which they are situated (Hannula, *et al.*, 2004:120).

2.8 AFFECT AND THE LEARNING OF MATHEMATICS

To fully appreciate the role of affect on the learning of Mathematics, it has to be studied in context of its impact on learners' achievements and performances and not be conducted in a disjointed manner. It is noted, however, that the inability of some learners to perform satisfactorily in mathematical tasks has, according to Liljedahl (2005:221), prompted the re-evaluation of the role of affect in the teaching and learning of Mathematics. Nevertheless, the importance of affect in an outcomes-focused curriculum is reported by Rhodes and Roux (2004:25) who posit that the multi-cultural and multi-religious character of South African society holds important implications for education, as the different values that are inherent in each belief system have to be accommodated in societal structures. Most teachers will be responsible for the implementation of CAPS from 2011 onwards and as a consequence will have to become sensitive (if they are not already) to the different values embedded in each belief system and all cultural orientations. The prevalence of affect constructs such as values and beliefs in the CAPS curriculum will have to be acknowledged, identified and promoted. At this juncture, the outcomes-focused curriculum does not cater for these variables as measurable indicators for achievement and performances and as predictors for success.

In order to provide a framework best suited to discuss the influence of affect on the learning of Mathematics, this study is predominantly framed around the so-called 3rd theoretical framework dealing with aspects of socio-constructivism and social context (refer to the study objectives in Chapter 1) and its impact on learning.

However, certain attributes of the other two theoretical frameworks for affect manifests themselves as supportive orientations to this study. The researcher accepts the attributes of an affective system that symbolically encodes essential information, as in the case of Mathematics, where encoding is done relevant to the person and in relation to the mathematical activities. For instance, the inability to solve a mathematical problem can result in encoding information about the state of the problem-solver. The beliefs that learners have about their inability to solve problems may result in the manifestation of anxiety and/or frustration (McLeod, 1992:579). To further encode the apparent lack of progress in solving a mathematical problem, after repeated efforts, may eventually evoke other feelings or attempts to change strategies in trying to solve the problem. There is also an acceptance that the affective system varies along a self-system of processes that could be fully functioning or defectively operating in respect to the learning of Mathematics. The self-system processes are the attributes of the personal learning processes, since learners as social individuals evaluate, develop and regulate themselves and their own affective experiences and learning processes in relation to Mathematics. "Self-system processes are connected with learners' experiences of self-worth, self-esteem and/or control with respect to the learning of Mathematics." (Malmivuori, 2004: 114). Learning theories encompass a broad variety of perspectives on learning, ranging from the traditional to the contemporary theories of learning. Learning is much more complex, and acceptable definitions are linked with the domains from which the concept is defined (Illeris, 2010:1). For instance, traditional learning has been understood mainly as the acquisition of knowledge and skills. However, today learning is much more than cognition. It now encompasses features of the conative and the affective. In Mathematics, one perspective on learning is the development of mathematical competencies (see paragraph 2.5.1). This perspective is supported by Illeris (2010:1), who states that learning sometimes takes on the nature of competence development. Learning theories are constantly being developed, some of them referring back to more traditional understandings, others trying to explore new ways of thinking such as encompassing societal and social dimensions. However, notwithstanding the overarching nature of elements of socio-constructivism and social context in this study, of particular interest to this study are the contemporary learning theories of Transformative Learning, Pragmatism and the Social Theory of Learning, although these theories are not the definitive foundations for the discussions on learning pursued in this paragraph or elsewhere in this thesis.

A synopsis of these theories is outlined below:

Transformative Learning

The concept of *transformative learning* was launched in 1978 by Jack Mezirow and is defined as the process by which we transform problematic frames of reference (mindsets, habits of mind, meanings) to make them more inclusive, discriminating, open, reflective and emotionally able to change (Mezirow, 2010:92). Of interest to this study, is that these transformative frames of reference are likely to generate affect constructs such as beliefs, attitudes, emotions and values that will prove justification for some learning functions or approaches. Transformative learning is a meta-cognitive epistemology of evidential (instrumental) and dialogical (communicative) reasoning. Mezirow (2010:93-94) lists the process of transformative learning as:

- reflecting critically on our own and others' assumptions;
- instrumental learning, determining that something is true (as it is purported to be);
- communicative learning, arriving at more justified beliefs by participating freely and fully in informed discussions;
- take action on transformed perspective – live what we become to believe until we encounter new evidence; and
- acquiring a disposition – to become critically reflective on our own assumptions and those of others, and to seek validation of our transformative insights through interaction with others.

Pragmatism

According to Elkjaer (2010:74), a theory of learning for the future that advocates the teaching of preparedness to respond in a critical manner to differences and includes an ability to act imaginatively in situations of uncertainties, is John Dewey's views on pragmatism. Dewey views experience as not being associated with knowledge, rather with human lives and living, and views the continuous meetings of individuals and environments as experimental and playful. That pragmatism is not yet acknowledged as a relevant learning theory may be due to the many interpretations in which Dewey defines experience in a way not well understood within education research and can be easily confused with experiential learning – that is, experience derived from bodily actions and stored in memory as more or

less tacit knowledge (Elkjaer, 2010:74). Even though a pragmatist is focused on outcomes, despite ideological and political differences, there is widespread acceptance that pragmatism views understanding of meanings of phenomena in relation to their consequences (Elkjaer, 2010:76). Dewey's future-oriented and experimental concept of learning serves as a comprehensive and contemporary theory of learning that emphasises creativity and innovation – and finds congruency with the epistemological orientation of this study (see paragraph 1.6) – that encourages critical and reflective thinking within mathematics education.

Social Theory of Learning

Wenger (2010:210) states that the primary focus of this theory is on learning as a social participation. Participation does not necessarily mean engaging in activities with certain people, but to a more encompassing process. Within mathematics education, and specifically within the parameters of learning Mathematics, the active participants can be viewed in relation to individuals (learners/students/teachers), classroom context and social context (see Figure 2.2) – the so-called communities of practice mentioned by Wenger. By engaging in the communities of practice, people discover meaning. Meaning becomes jointly constructed in the sense that it is neither handed down ready-made nor constructed by individuals on their own (Malmivuori, 2004:119). The adage that learning takes place within the life-world and life-experience of the learner is supported by the fact that Wenger (2010:213) purports that we can all construct a fairly good picture of the communities of practice we belong to now (life- world), those we belonged to in the past (life-experience) and those we would like to belong to in future. It is within these communities of practice that we should consider our own learning as Wenger does not view learning as a separate entity or activity. According to Malmivuori (2004:115), learners' affective responses to the learning of Mathematics are intertwined with their learning contexts and social environments (communities of practice) and are not seen in isolation or as separate. The key epistemological orientation of this theory is acknowledged in this study, namely the premise that we are social beings central to learning, and that our ability to engage and experience social relations should produce meaningful learning. Within affect, meaningful learning may however become compromised by the direction, degree and intensity of the affect constructs/variables. The learning of Mathematics can become negative and inhibiting in nature, resulting in the disturbance of learners learning of Mathematics.

The affective responses to the learning of Mathematics do not only arouse, tone or disturb learners learning, but serves as a significant source of information about their (learners) own mental content and ongoing mental processes. The manner in which affect and its constructs have been dealt with as a field of study may not have endeared itself too much in the past as a field of interest for investigation by researchers of mathematics education. In mathematics education, affect has typically been approached through psychology. Considering affect as a biological or social phenomenon might open up a new perspective on its influence on the teaching acts and the learning functions (Hannula, *et al.*, 2009:32).

Returning to the topic discourse of paragraph 2.8, still much has to be done and clarified in the realm of affect in mathematics education. A dissenting view is given by Liljedahl (2005: 221) who posits that “the inability of research to explain the failures of learners in problem-solving contexts, and who possess the cognitive resources necessary to succeed, has prompted the re-evaluation of the role of the affective domain in the learning of Mathematics”. The view of Pintrich and Schunk (2002:277) are that modern cognitive models, though not intentionally designed to ignore affect, emphasise rational and technological knowledge rather than affective or emotional processes. After all, if the guiding metaphors for cognition and learning are the computer and information technology, it is fairly easy to see why current researchers will find it difficult to investigate affect or give it a central role in their theories (Pintrich & Schunk, 2002:277). However, the general *zeitgeist* of earlier research in mathematics education does not negate or diminish the role of affect, it has rather laid the foundation for present day research to explore all avenues that may contribute to the understanding of how learning takes place. Assessing the influence of affect on learning requires delineating the constructs of affect, namely, beliefs, attitudes, emotions and values into their respective variables such as *attitudes towards mathematics*, *beliefs about mathematics*, *emotional reactions towards mathematics* and *values about mathematics* (as identified earlier in this chapter).

Initially, research on affect in mathematics education focused primarily on *attitudes towards mathematics* but later became broadened to include research on *beliefs about mathematics* and *emotional reactions towards mathematics*.

A fourth affect construct, *values*, was later introduced by DeBellis and Goldin (1997:209) leading to the so-called tetrahedron model for affect. Each vertex of the tetrahedron (emotions, attitudes, beliefs and values) can be considered as interacting dynamically with one another. For example, emotions can influence the attitudes, beliefs and values of a person. The mechanism for this particular influence is the construction of structures as a result of the recurrence of certain affective pathways. According to Goldin (2004:112), of noted interest is that “each vertex interacts interestingly with the corresponding component in the affective domain of other individuals”. The magnitudes of affect constructs can be described along a continuum ranging from the most intense and least stable (emotions) to the most stable and least intense (beliefs), with attitudes somewhere in between. In the past, beliefs were seen as closer to the cognitive and emotions being the furthest away.

The interrelatedness of affect constructs and their variables are reported on in this chapter. Because of their stable nature, research on affect has focused primarily on the influences of attitudes and beliefs on the learning of Mathematics (Op’t Eynde, De Corte & Verschaffel, 2001:25). According to Leder (1992:33), as well as Ponte, Matos, Guimarães, Cunha Leal and Canavarro (1992:218), beliefs and attitudes are strongly linked to school achievement and consider these two affective constructs as the gatekeepers of learning.

Notably, most measures of attitude in past research were once-off and static and longitudinal measures in attitudes were often lacking. Anderson (2007:164) declares that whether or not attitude change is a goal of general education, the measurement of such change is vital in order to allow teachers to become aware of the effects of their classes on learners as going beyond the normal acquisition of knowledge and skills. Furthermore, measuring attitudinal change allows researchers to gain insight into whether the curriculum is creating changes in values that are not intended. Within the ambit of this study, the influence of affect on the learning of Mathematics was reviewed as part of the literature study.

2.8.1 Attitudes

In the context of mathematics education, feelings and moods, confidence, frustration and satisfaction are all used to describe responses to mathematical tasks (McLeod, 1992:576). Often these feelings are defined as *attitudes* even though the term does not seem adequate to describe some of the more intense emotional reactions that occur in mathematics classrooms. McLeod (1992:581) defines attitude as *the affective responses that involve positive or negative feelings of moderate intensity and reasonable stability*. He reports that many researchers in differential psychology and social psychology have given substantial attention to the notion of affective issues, especially to the study of attitudes from various theoretical perspectives (see Table 2.2).

Today, most researchers agree that attitudes are acquired and therefore “subject to fairly predictable change” (Simonson & Maushak, 2001:84). Several researchers, such as DiMartino and Zan (2001:209) and Hannula (2002:25), have pointed out that “attitude is an ambiguous construct which is often used without proper definition and needs to be further developed theoretically”. Several theories can be associated with the formation of attitudes and changes in attitudes. Table 2.2 provides an overview of the basic premises and key instructional implications associated with attitudes. Traditional and contemporary cognitive theories about attitudes are clearly shown in this table.

Many reviews of related literature on affective factors and mathematics education have been undertaken, generally focusing on *attitudes towards mathematics* as their major concern (see Aiken (1970, 1976), Kulm (1980), Reyes (1980, 1984) & Leder (1987)). *Attitudes towards mathematics* are invariably linked to the degree of attitudes that can range from negative to the positive, as well as to its intensity (level of commitment) towards the learning of Mathematics. Because *attitudes towards mathematics* cannot be directly observed, they are inferred from behaviour, usually in the form of verbal responses or observable actions during the learning of Mathematics.

Table 2.2: Defining Attitudes within Different Theoretical Frameworks

Theory	Basic Premise(s) of Theory	Suggested Intervention(s)
Behavioural	Learning occurs when behaviour is positively reinforced.	Have learner act out behaviours consistent with desired attitude. Provide positive reinforcement.
Cognitive dissonance	Unstable state created when attitudes are inconsistent with behaviour.	Create dissonance. Provide means to reduce dissonance - free to make attractive choices.
Affective-cognitive consistency	Unstable state created when attitudes are inconsistent with knowledge.	Change cognitive component first by providing new information.
Social judgment	Existing attitudes surrounded by latitude of acceptance.	Incremental provision of messages within (ever shifting) latitude of acceptance.
Social learning	Individual learns attitudes by observing and imitating the behaviour of others.	Provide powerful model. Multiple models doing same thing.
Functional	Purposeful attitude serves persons who hold it and determines best method for changing it.	Acknowledge ego-defensive role of attitudes related to self-concept.
Krathwohl's taxonomy	Intensity of given attitude built through successive stages.	Learning at a given level depends on prior learning at lower levels.

Citation: Miller (2005)

A positive *attitude towards mathematics* in this study refers to the way or manner in which learners view their experiences with Mathematics in terms of helping them to learn Mathematics, making their learning more enjoyable, motivating them to learn more and increasing their confidence in their academic achievements and performances in Mathematics. This view about *attitudes towards mathematics* is supported by Ernest (1988: 290) who refers to it as a combination of the degree of learners' liking of the subject and confidence in their mathematical ability. However, concerns for the multi-dimensionality of the *attitudes toward mathematics* variable led to the design of a Mathematics Attitude Inventory with six scales.

Other attitude instruments have also been developed but the most influential measures have been the Fennema-Sherman Mathematics Attitude Scales. Although the Fennema-Sherman attitude scales were developed for the purpose of research on gender-related differences in mathematics achievement, their impact was felt widely in all research on *attitudes towards mathematics* (McLeod, 1994:639).

According to McLeod (1994:638), one of the major concerns of earlier research on attitudes was the quality of the instruments that were used. McLeod states that some instruments focused only on one attitude dimension. An earlier study undertaken by Bessant (1995:342-343) investigated the interrelatedness of various types of mathematics anxieties with attitudes towards mathematics, learning preferences, study motives and study strategies. He reports that factor analysis indicated that, much like mathematics anxiety, attitudes towards mathematics and preferential orientations to learning should be treated as multi-dimensional phenomena. Learners' attitudes towards mathematics appeared to be interwoven with the facilitating and debilitating effects of mathematics anxiety. Hembree (1990:46) reports a strong association between mathematics anxiety and attitude. He reports on a study undertaken that showed that an unfavourable attitude regarding mathematics is linked to high incidences of mathematics anxieties among pre-service student teachers. Minato and Kamada (1996:96) state that teachers need to be aware of the relationship between attitude and achievement and that an attempt needs to be made to determine the causal pre-dominance between these two variables in the bi-directional effects they have on each other. Several studies have indicated a strong bond between attitudes and academic achievements (Husèn, Fagerlind & Liljefors, 1974; Knaupp, 1973).

Maree, Prinsloo and Claasen (1997:3) state that there is a statistically significant association between aspects of study orientation in mathematics and achievement, attitude and anxiety. Snyders (2008:236) proposes that learners who do not have a belief in being successful in Mathematics, do not have a good chance of doing well. Rather a positive attitude can contribute in believing in one's own (mathematical) abilities. According to Liljedahl (2005: 221), attitudes are the manifestations of beliefs. Negative beliefs about mathematics may result in an unfavourable attitude towards mathematics.

A belief that Mathematics is “difficult” or “just calculations” or “just for the bright learners” may manifest itself as an attitude of disregard for explanations. Attitudes, like beliefs, are stable entities: they are slow to form yet difficult to change.

2.8.2 Beliefs and Belief Systems

Earlier studies on the other affective components, in particular beliefs and belief systems, were undertaken mostly by social psychologists in the study of the nature of beliefs and their influence on people’s actions. In the 1980s, there was a resurgence of interest in the field of educational research in beliefs and belief systems. This marked a shift away from the process-product paradigm that focused primarily on behaviourism to a study on identifying and understanding the composition and structure of *belief systems and conceptions, action mind frames* and on *thinking and decision-making* (Thompson, 1992:129).

2.8.2.1 Defining beliefs and belief systems

To distinguish between *knowledge* and *belief*, a characterisation of knowledge is the general consensus regarding procedures for evaluating and judging their validity (Thompson, 1992:129). Knowledge must satisfy certain criteria involving canons of evidence. Beliefs, on the other hand, are often held or justified for reasons that do not meet these criteria and are often characterised by a lack of agreement on how they are to be evaluated or judged (Thompson, 1992:130). It is not an uncommon perception though to treat a set of beliefs as a specific domain of knowledge. A thorough treatment of this argument, however, lies outside the purview and intent of this study. Nevertheless, such a set of organised beliefs based on evidence becomes knowledge and Philipp (2007:267) posits that “a belief is not knowledge unless it is true”. In retrospect, Goldin (2002a:64) questions this truth requirement that some researchers have attached to beliefs by questioning the definition of knowledge as *justified true beliefs*. This definition makes it difficult to differentiate between beliefs that are in fact true, valid, correct, rational or veridical from those beliefs that are in fact false, incorrect, invalid, irrational or illusory.

According to Philipp (2007:259), “Thompson seemed to think of beliefs as a subset of conceptions and that her definition of conception included beliefs but at times seem to use these terms interchangeably”. Philipp (2007:267) accepts a conception as a belief if a person could respect a position that is in disagreement with the conception as reasonable and intelligent. Hannula, *et al.* (2004:110) reports on the research undertaken by Furinghetti and Pehkonen in 2002, when trying to provide an appropriate and encompassing definition for beliefs. According to Hannula, these two researchers embarked on interviewing a panel to evaluate the definitions given to this variable in the literature. They found that no definition could be accepted by all experts in the panel but many closely related ones were. They concluded that the category of beliefs, namely *belief systems* can be viewed as the way in which one’s beliefs are arranged within such a category that focuses around a specific idea or object. Nespor (1987:321) puts forward that “belief systems often include affective feelings and evaluations, vivid memories of personal experiences and assumptions about the existence of entities and alternative worlds, all of which are simply not open to outside evaluation or critical examination in the same sense that the components of knowledge systems are”. In addition, Thompson (1992:130) defines “a belief system as a metaphor for examining and describing how an individual’s beliefs are organised”.

Underlying some beliefs is an assumption that mathematical knowledge is crucial for teachers before they can help learners learn. One of the most widely held beliefs of why learners do not do well in Mathematics is the inadequacy (due to the static nature) of their teacher’s knowledge of Mathematics. Kaiser (2006:395) states that while beliefs concerning the teaching of Mathematics are predominated by static aspects, the beliefs regarding the learning of Mathematics are more dynamic.

In spite of the believe in the importance of mathematical knowledge and the evidence that some teachers do not have adequate knowledge of Mathematics, it is generally accepted that the Mathematics that learners are taught must be put into a framework that is understandable to them. Mathematics must be translated for learners so that they can see the relationship between their (learners) knowledge and the new knowledge that they are to learn. Knowledge on how learners think can be used by the teacher in decision-making for the planning of classroom teaching. Knowledge derived from learners’ beliefs can be used by teachers in a way that has an impact on education outcomes (Thompson, 1992:135).

2.8.2.2 *Students' beliefs about mathematics*

The way learners think about Mathematics is contingent to the beliefs they have about Mathematics. By acknowledging and accepting the multivalent constructs of learners' beliefs, the learning of Mathematics can be moderated accordingly. This is akin to accepting the fact that learners possess *beliefs about mathematics* (metaphorically they are sometimes regarded as empty slates – *tabula rasa*) that allow them to construct meaning and relevance through their own experiences and social interactions. Halverscheid and Rolka (2006:233), by citing Ernest (1988, 1991), employ the notion of dividing *beliefs about mathematics* into three categories:

- The *instrumentalist view*: Mathematics is seen as a useful but unrelated collection of facts, rules, formulae, skills and procedures.
- The *Platonist view*: Mathematics is characterised as a static but unified body of knowledge where interconnecting structures and truths play an important role.
- The *problem-solving view*: Mathematics is considered as a dynamic and continually expanding field in which creative and constructive processes are of central importance.

Kaiser (2006:394) notes that the classification system of mathematical beliefs developed by Grigutsch, categorises learner beliefs mainly by four aspects that relate to the nature of Mathematics as a discipline, namely:

- as a science which consists of problem-solving processes (*aspect of process*);
- as a science which is relevant to society and life (*aspect of application*);
- as an exact, formal and logical science (*aspect of formalism*); and
- as a collection of rules and formulae (*aspect of scheme*).

Both sets of categories are accepted in this discussion since it may be argued that the beliefs and belief systems of teachers, students and learners can be particularised to any of these categories. Learners' (as well as students') beliefs about the learning of Mathematics and about their mathematical competencies can be summarised, *inter alia*, as follows:

- Many learners believe that problems can be solved quickly or not at all and that only geniuses can be creative in Mathematics.
- Most learners believe that even though Mathematics is important it usually involves mainly memorisation and following rules.
- Learners' beliefs that, in order to develop mathematical expertise, they should be curious about mathematical ideas, develop mathematical intuition and analytical skills.
- Traditionally learners view Mathematics teachers as possessors of mathematical knowledge that should be imparted to them (learners).
- Some learners believe that the Mathematics teacher should guide them through teaching of algorithms (steps) and that they (learners) should finish the problem or do consolidation (tasks, assignments, homework) based on the guidance received.
- Learners come to mathematics classrooms expecting participation that includes working in textbooks, solving pages of problems and listening to teachers' explanations.
- Learners typically do not see explaining their own thinking as part of doing Mathematics.
- Some learners believe that Mathematics is a male domain.
- Learners' belief that correct answers are more important than the reasoning processes.
- Learners view that the relationship they develop with Mathematics influences how they participate and how they make sense of Mathematics.
- Mathematics learners view themselves as often located within identities of achievements: successful versus struggling.
- For many learners studying Mathematics in school, the beliefs they have towards the subject are as important as the knowledge they learn about the subject.

Liljedahl (2005:221) states that “*beliefs about mathematics* are often based on their (learners’) own experiences with Mathematics” while Evans and Zan (2006:44) contend that “learners’ mathematics-related beliefs together with mathematical knowledge, underlie learners’ understanding of and functioning in the mathematics classroom”. However, learners’ beliefs about their learning of Mathematics and their abilities to do Mathematics do change as they grow older. As many researchers have pointed out, learning and success in Mathematics are influenced by learner beliefs about Mathematics and about themselves as Mathematics learners (see Hannula, *et al.*, (2004)). Beliefs can be held with differing degrees of strength – the stronger the belief, the more difficult it becomes for the learner to accept alternative paradigms of thinking. Likewise, the weaker the beliefs, the easier or more acceptable it becomes to re-evaluate one’s own thinking and become more accommodating to other views. Nevertheless, there is support in research for the claim that learners’ and teachers’ beliefs have a definitive influence on classroom practice.

2.8.2.3 Teachers’ beliefs about mathematics

The way teachers approach Mathematics depends fundamentally on their system of beliefs, especially on their conceptions of the nature of Mathematics, the meaning of Mathematics, and their perceptions of their learners’ mathematical competencies. According to Kaiser (2006:396), the leading criterion was that teachers could be classified exactly in accordance with one of the four streams (see paragraph 2.8.2.2) of beliefs about mathematics.

- Teachers with a process-oriented belief system will stress the many opportunities for developing solutions and will reduce emphasis on application and modelling.
- Teachers with schematic mathematical beliefs will restrict applications and modelling to examples that will enable easy mathematisations or lead directly to a formula.
- For teachers with formalistic beliefs, the context does not play a role.
- In the application-oriented beliefs, real-world context plays an important part in the modelling process.

Thompson (1992:131) posits that “teachers’ beliefs can be distinguished, *inter alia*, by whether they refer to the nature of Mathematics as a discipline or to the teaching and learning of Mathematics”. Teacher beliefs are concomitant to teacher efficacy. Teacher efficacy is the belief that he/she can influence learners’ achievements. Pitkäniemi (2002:135) contends that “a teacher with high self-efficacy beliefs promotes learners’ motivation, learners’ self-esteem, self-direction, pro-social attitudes and positive attitudes”.

Taimalu and Õim (2005:178) state that “teacher efficacy beliefs and particularly their development, can be seen as one aspect of a teacher’s professional development”. Knowledge of a teacher’s efficacy beliefs, are necessary for understanding the developmental possibilities of learners. Another aspect of research into teachers’ beliefs is their conviction that their own impact on learners’ beliefs is high (Chapman, 2001:233). More so, to understand the mathematical competencies of learners through a framework of belief systems allows teachers some insight into how and why learners engage with Mathematics. However, Eichler (2006:17) notes that research has as yet yielded few results which facilitate understanding the relations between teachers’ and learners’ beliefs.

Some of the teachers’ beliefs are listed below (Thompson, 1992:131,135-137):

- Beliefs appear to act as a filter through which they can interpret and give meaning to their experiences as they interact with learner and the subject matter.
- Many of the beliefs and views seem to originate in and are shaped by their own experiences in the classroom.
- Beliefs in how learners think about Mathematics may be influenced by identity and culture.
- Teachers appear to evaluate and reorganise their beliefs through reflection, some more than others.
- Some believe that the way materials are being used to portray Mathematics needs to be examined, as well as being sensitive to the messages and meanings that are communicated to the learners.
- Some believe that learners cannot solve problems on their own without instruction.

Teachers' beliefs can often change, be it partly to (*inter alia*) change in behaviour, reflection or as a result of observing learners' mathematical reasoning. Similarly, to change learners' beliefs, the strength of their (teachers') conviction and perceptions underscores their (learners') ability to undergo change.

In the case of South Africa, the change to an outcomes-based curriculum left many teachers, especially those with many years of teaching experience, bewildered and confused. These teachers who had taught a traditional pedagogy now found themselves having to embark on being retrained in a methodology which seemed foreign to them. Their deep-seated beliefs in their own abilities made the transition even more difficult as their roles as teachers became redefined. According to Cross, Mungadi and Rouhani (2002:172), curriculum reform in South Africa has resulted in several structural and policy tensions within the education system. Most notably, was the emphasis on achieving expected outcomes (critical, developmental and learning outcomes – now encapsulated as the general and specific aims in the CAPS) *vis-à-vis* the capacity of teachers to translate them within the realities of the “transformed” classroom. Through teacher hearings and submissions a sense of teacher beliefs around the new curriculum could be formed and centred around, *inter alia*:

- that there was too much administrative work, leaving little time for actual classroom teaching;
- that outcomes were over-specified leaving them with little space for discretion and creativity;
- that content and knowledge were under-specified;
- that they were not properly consulted in the design of the new curriculum;
- that the terminology used in education documents was complex and cumbersome; and
- that they received inadequate orientation and training.

[See *Report of the Review Committee on Curriculum 2005*, as cited by Cross, *et al.*, p. 182 and the *Report of the Task Team for the Review of the Implementation of the National Curriculum Statement, 2009*.]

The researcher, in discussion with post-graduate students (Bachelor of Education, Honours course) from the NIHE, as well as with a Foundation Phase teacher³, noted that their beliefs about teaching are still firmly entrenched within the traditional pedagogy, notwithstanding the fact that South Africa has implemented its new curriculum for more than a decade. There is now strong support in government to revisit some aspects of traditional pedagogy, especially in literacy and numeracy through the introduction of the *Foundations for Learning* programme in primary schools and the phase implementation of CAPS for each of the Learning Areas (subjects). The beliefs and belief systems of both learners and teachers are important considerations when designing intervention programmes, such as the ones mentioned above, since these programmes can provide some form of remediation to the intensity inherent in beliefs and emotions. According to Evans and Zan (2006:44), given the close relation between beliefs and emotions, investigation of learners' emotions can enhance better understanding of their beliefs.

2.8.3 Emotions

With regard to emotions, some researchers such as Goldin (2000), Lazarus (1991), Mandler (1989) and Power and Dalgleish (1997), who have studied the psychology of emotions using different approaches, have concluded that there is no definitive agreement on what emotions are based on. Phillips (2003:190) states that there is at present no generally accepted theoretical framework for human emotions. Evans and Zan (2006:46) call for the inclusion of emotions within a theoretical framework – for a need to better understand a learner's mathematical behaviour. The complexity of the concept of an emotion has ensured that no single paradigm of an emotion can be used as an *a posteriori* model from which to generalise.

Pintrich and Schunk (2002:280) state that emotions are often the dependent variable that flows from various cognitive and appraisal processes. Mandler (1984:173) proposes that a major source of emotion is the interruption of a person's plans or planned behaviour.

³ Information gathered during informal feedback during contact sessions and personal discussions in 2010.

In psychological terms, when an interruption occurs, the normal organised sequences or patterns of thought or action cannot take place, resulting in physiological arousal of some sort (muscle tension or rapid heartbeat, for example). McLeod (1988:134) concurs with the description given by Mandler on how interruption and physiological arousal can lead to emotions. Even though Mandler does not make special reference to sensation as a type of physiological arousal, Hacker (2004:201) states that emotions are not necessarily linked to localised sensations in the same way as appetites are.

Some emotions are associated with sensations, such as fear and rage whereas others are not (pride, envy, remorse). There is no feeling of pride in one's stomach neither is there rage in one's knees. Some less intensive emotional states which are not addressed in Mandler's deposition are presented by Hannula, as cited by Philipp (2007:299), who argues that he rather consider learners' reactions when thinking about Mathematics than the interruptions that occur while learners are in the process of engaging in Mathematics. Though research into the causes and activation of emotions primarily resides in the ambit of neuroscience and cognitive psychology⁴, Hacker (2004:204) suggests that what is crucial for the identification of an emotion is not its cause (or activation) but its object.

In support of footnote 4, emotions are normally associated with objects (for instance, being angry with oneself or someone, hating a person or a job or when one feels pride, enjoyment, anxiety, *etc.*), or it may be with a situation or an event (Hacker, 2004:204). One cannot measure a person's emotions by his/her intensity or repeated occurrences (Hacker, 2004:203). Rather, the strength of emotions can be determined by the extent to which they manifests themselves in behaviour over time and the type of behaviour that is being displayed.

⁴ The causality of emotive states may well lie in these ambits. However it is the opinion of the researcher that emotions towards mathematics specific (be it positive or negative) are developed over time and are thus not epigenetic.

For example, anger may be exhibited in episodic outbursts over a short period of time but may not be sustainable over a longer period. Gratitude, on the other hand, may not be short-lived as the endeavours to show appreciation may last longer. In comparison with other affective constructs, emotions are relatively unstable. The sudden outburst of anger, joy, jealousy, *etc.*, can be followed by an immediate dissipation or dissolution of these emotions (Hacker, 2004:201).

From an education perspective, a general taxonomy of emotions is shown in Table 2.3 and indicates the specific emotions that may be engendered in achievement contexts. Two categories are identified: task-related and social. The emotions of learners and students when involved in any type of learning task are appropriately designated as task-related. Within the task-related category a distinction is made between emotions that are experienced when actually engaging in the task (process-related), the emotions experienced by learners and students when they approach a task (prospective) and the emotions experienced by the learners and students when a task is completed (retrospective). The potential emotions generated from social interactions with other individuals are referred to as social-related. Elaborating on the dimensions, this discussion focuses on the positivity/negativity of the emotions which are synonymous with feelings of pleasantness/unpleasantness.

The taxonomy of learner emotions is not definitive, as current research in social cognitive theories and affective models can provide additional categories and dimensions. Since emotions are the least stable of affect constructs it has received little attention to its role in the learning of Mathematics (*Emotional reaction towards mathematics* is the variable to the affect construct: emotions). For Liljedahl (2005:221), emotions are rooted more in the immediacy of a situation or mathematical task and as such the results are often fleeting. This does not necessarily mean that one has to discount the role that emotions play in the teaching and learning processes.

By examining the feelings (that are emotion-based as opposed to feelings of sensation) of learners towards mathematics and about their doing Mathematics can contribute greatly to improving learning and performances.

Table 2.3: Taxonomy of Student Emotions

Task-related		
Dimension	Positive	Negative
Process-related	Enjoyment	Boredom
Prospective	Hope Anticipatory joy	Anxiety Despair/Hopelessness
Retrospective	Relief Outcome-related joy Pride	Sadness Disappointment Shame/Guilt
Social-related		
Dimension	Positive	Negative
	Gratitude Empathy Admiration Sympathy/Love	Anger Jealousy/Envy Contempt Antipathy/Hate

Citation: Pintrich and Schunk (2002)

The role of emotions when learning Mathematics, according to Op't Eynde (2004:121), necessarily implies “viewing emotions as consisting of multiple component systems that regulate each other in a specific context”, for instance the mathematics classroom; and “viewing learning as an engagement in the practices of a specific community that maintains the person’s interpersonal relations and identity in a particular social context”. Op't Eynde agrees that both views provide a comprehensive and promising theoretical framework for the study of the role of emotions in the learning of Mathematics, as well as the emotional reactions towards mathematics. Emotional reactions can be viewed as being defined within the parameters of emotional perturbations. (Also see Hacker (2004:202) for *Conceptual links of emotional perturbations.*)

Evans and Zan (2006:43) aver that teachers should become sensitive to the often neglected importance of emotions in the learning and use of Mathematics. Teachers’ knowledge of learners’ emotions can lead to a positive impact on learner achievements and performances. An often neglected field of research in emotions is the emotions of teachers. As much as the consideration of learners’ emotions can affect learning and performance, so too should the acknowledgement of teachers’ emotions inform the teaching and learning processes.

Geert (2005:995) argues that teachers' emotions have to be understood in relation to the vulnerability that constitutes the teaching job. In South Africa, the emotional impact that the new outcomes-based curriculum has had on teachers was that it posed definite challenges to them (*researcher's contention*). In context of their profession, it can be argued that age, generation and biography exhibited some degree of structural vulnerability to these teachers. Exposure to the different normative standards that they as teachers see as being imposed on them may have resulted in generating, to some degree, emotions of resistance.

Intense emotions towards the then new curriculum (Curriculum 2005) could have resulted in varying degrees of resistance or some proactive attempts to influence or change their situation (in a professional context). Such human behaviour is not only emotionally driven but also the extent to which individuals view themselves as professionals as guided by their value-priorities. Hill (2008:102) regards the priorities which individuals and societies attach to certain beliefs, experiences and objects as a deciding factor on how people should live and what they should treasure. For Hill, attaching a value-priority is a process which melts the mind and emotions.

2.8.4 Values

The concept of *value* can imply a person's accepted principles or standards. Individuals rely on a wide variety of influences, including their own personal experiences and mistakes to shape their values. Within the context of time spent on researching the earlier-mentioned affective constructs, values are probably being used the least. Unlike McLeod who sub-categorised affect into attitudes, emotions and beliefs, a fourth affect construct, *values*, was later introduced by DeBellis and Goldin (1997:209). Goldin (2002a:60) states that values (as well as ethics and morals) relates to deeply held preferences that may be characterised as personal truths.

Schunk (2004:384) posits that "values have a direct link to achievement behaviours such as persistence, choice and performance and may relate positively to many self-regulatory processes such as self-observation, self-evaluation and goal setting". However, values education is a dominant theme in the goals of various education systems around the world

and it is “important to explore what a research focus on values in mathematics education can offer to our concerns about affect” (Bishop, 2001:93). Questions have arisen though as to whether value education belongs in the classroom. Many teachers, without conscious planning and preparation, factor in some form of value attributes in their lessons. According to Hill (2008:102), it is imperative that teachers acknowledge that they teach values in the course of everything they do, from the moment they engage with the school culture. To do so with conscious intent and moral sensitivity, teachers need to understand the various levels on which learners may respond to their teaching. Past research conducted by Harris and Associates (1996:4), on behalf of The Metropolitan Life Survey of the American Teacher reports:

- that for many learners, values and principles of right and wrong belong in the classroom;
- that a sizable majority (63%) feel that lessons on values and principles belong in the classroom;
- that female learners show more support for teaching values than male learners (68% vs 58%); and
- affirmative support for the inclusion of value education in the classroom.

The importance of value education in the classrooms of South Africa is noted through the inclusion of value-oriented principles in the curriculum (DBE, 2011b:4-5) such as:

- independence
- creativity
- co-operation
- a sense of responsibility
- inquisitiveness
- communicativeness
- environmental consciousness
- tolerance

The above value-oriented principles find expression in the Revised National Curriculum Statement (RNCS) and the National Curriculum Statement (NCS) and are rooted in the ten fundamental values noted in the Constitution of South Africa (DoE, 2001:7). These are:

- Democracy
- Social Justice and Equity
- Non-racism
- Non-sexism
- *Ubuntu* (human dignity)
- An Open Society
- Accountability
- Respect
- The Rule of Law
- Reconciliation

To further provide *a fortiori* the inclusion of values in the mathematics classroom the following deposition is presented. The intent of the researcher is to provide another dimension in the research on values. Like previous affect constructs in this study, the (affect) construct *values* is associated with its variable *values about mathematics*. To provide more depth to this variable, it is sub-categorised into *values about self* and *values about task*. The intent of the sub-variables (referred to as value variables) is to provide added perspectives to the learning of Mathematics within the ambit of values about mathematics. The possibility exists too in establishing some form of coherence or linkage with two of the concerns categories of Fuller (see Chapter 3). (The proposition of the above-mentioned value variables is open for review and comment by other researchers.)

The underlying assumption in proposing these two value variables is the notion that some studies on affect, especially dealing with the role of affect on the learning processes, address the influence of affective variables on *why* students (and learners) learn and *how* students (and learners) learn.

The *why* of learning Mathematics can be considered within the ambit of *values about self* while the *how* of learning Mathematics within *values about task*. In mathematising this discussion, a working definition in analysing *values about self* entails identifying what values students (and learners) think they should have in order to be successful in Mathematics. The predictors for *self* include the attributes of integrity, sensitivity, self-efficacy and self-esteem and are explicated in Table 2.4 through the formulation of questions pertaining to the essence inherent in their definitions. These predictors for self have been formulated using the foundational attributes inherent in the 2nd theoretical framework for affect (see paragraph 2.7.2). The value variable of *values about task* entails the notion of what values students (and learners) should possess in order to complete a mathematical task successfully. The predictors of *task* accommodate the attributes of perseverance, endeavour, interest, incentive, attainment and satisfaction. The values of students (and learners) can be basically intrinsic in nature and can influence the way they learn Mathematics.

Although a complete and thorough discourse of how these predictors may impact on these categories is lacking, the researcher acknowledges that other predictors may also have an impact on these categories and needs to be further explored empirically. The theoretical underpinning for these value variables lies within the frameworks of social cognitive models such as the *Expectancy-Value models*, the *Ability models* that deal with how cognitively learners engage in tasks and their use of different cognitive or meta-cognitive and self-regulatory strategies and the *Attributional models* which is a cognitive theory of motivation and based metaphorically on individuals as conscious and rational decision makers. The proposed value construct (see Table 2.4) does not consider the casual determinants inherent in these support theories but uses aspects of their attributes in defining the predictors of the two suggested value variables of *self* and *task*. The value construct measurement (for this study) is purely qualitative and no quantitative measurement of the value variables and their predictors are intended.

Table 2.4: Values Constructs in relation to the Learning of Mathematics

Value variable	Predictors
Values about self	<p><i>Integrity</i> Do I <u>genuinely</u> like Mathematics? Am I <u>committed</u> to do well in Mathematics? Is it <u>worth</u> my while doing well in Mathematics?</p> <p><i>Sensitivity</i> How do I <u>feel</u> when I under-perform in Mathematics? Am I <u>fearful</u> of criticism?</p> <p><i>Self-efficacy</i> Will I be <u>able</u> to do Mathematics? How will I be able to <u>cope</u> with Mathematics?</p> <p><i>Self-esteem</i> Am I <u>good</u> at Mathematics? Do I have the <u>ability</u> to do well in Mathematics?</p>
Value variable	Predictors
Values about task	<p><i>Perseverance</i> How <u>long</u> must I spend doing a mathematical task? Do I <u>give up</u> easily when performing a task?</p> <p><i>Endeavour</i> What <u>effort</u> must I put in to do a task? What must I <u>strive</u> for when performing a task? What must I <u>try</u> to achieve in a task?</p> <p><i>Interest</i> How <u>curious</u> am I to perform a mathematics task? Of what <u>concern</u> is Mathematics to me? Am I <u>attentive</u> enough while performing a task? Am I <u>inquisitive</u> about the mathematical task?</p> <p><i>Incentive</i> Does the mathematical task <u>motivate</u> me enough to complete it? Am I <u>spurred</u> on by the task at hand? Does the task <u>incite</u> me to do well?</p> <p><i>Attainment</i> How have I <u>accomplished</u> the task? Did I arrive at <u>achieving</u> the outcomes of the task? What have I <u>gained</u> by doing the task?</p> <p><i>Satisfaction</i> Have I met the <u>expectations or requirements</u> of the task? Am I <u>content</u> with the efforts I put in while doing the task? Have I <u>complied</u> with all the task instructions?</p>

The proposed value constructs lend themselves to further research that can be undertaken to explore these value variables and their predictors within the parameters of learning Mathematics. For the sake of clarity, it is noted that discussions on values education is not pursued in this study, since it involves teaching values with conscious intent and that cognition is acknowledged as having a modest yet subsequent role in value formation than it might suggest (Hill, 2008:102).

2.9 THE INTERRELATEDNESS OF AFFECT VARIABLES

The considerations of the interrelatedness of the affective variables and their influences on aspects of the cognitive domain are reported in various research literature (as discussed in this chapter). According to Philipp (2007:311), the research on affect has grown from psychological theories of learning that focused on the contents of the minds of individuals, and of which the field has now progressed to adopting socio-cultural theories through which researchers look at the world anew (a post-modernistic perspective). The use of words like *attitudinal emotions*, *emotional values*, *etc.* in contemporary research shows how traditional affect constructs can now be interpreted in terms of their overlapping definitions or their interrelatedness or influences they exert on another when attempting to explain the role of affect on learners and students. This paragraph reports on the work of some researchers who have undertaken studies to investigate these relationships among affect variables.

Liljedahl (2005:219) reports that his results indicate that an AHA! experience – defined as the moment of illumination in the wake of lengthy, and seemingly fruitless, intentional effort – “has had a transformative effect on learners’ affective domains, creating positive beliefs and attitudes”. He further posits that “attitudes may be thought of as the responses that students have to their belief structures: that is, attitudes are the manifestations of beliefs” (p. 221). Op’t Eynde, De Corte and Verschaffel (2001:25) suggest that “because of the stable nature of beliefs and attitudes (in relation to emotions) research has primarily focused on their roles in the learning of Mathematics”.

Research indicates that success and feelings of accomplishment contribute to a change in attitudes and beliefs (see Ponte, Matos, Guimarães, Cunha Leal & Canavarro (1992), as well as Leder (1992)). Heirdsfield and Lamb (2006:282) note that “in changing from an old mathematics syllabus to a new one requires a significant shift in beliefs and attitudes about teaching content and pedagogy”. According to Liljedahl (2005:222), “changes in beliefs and attitudes are generally achieved through the emotional dimension” – repeated negative experiences will eventually produce negative beliefs and attitudes, and likewise, repeated positive experiences will produce positive beliefs and attitudes. Philipp (2007:265) reports on the research undertaken by others in distinguishing between beliefs and values. He states that “beliefs tend to be associated with a true/false dichotomy whereas values are often associated with a desirable/undesirable dichotomy”. Evans and Zan (2006: 41) report that “volatile emotions can be seen as the basis for more durable attitudes and beliefs”. Hill (2008:101) states that “the teaching of beliefs and values is often turbid because the two terms tend to be used interchangeably”. The relationship between affect and other non-affective constructs is as important to mathematics education researchers as the affect domain itself. Noted below is some related research done on the influences of affect on other aspects of teaching and learning.

Ma and Kishor (1997:27) note the perceived link between learners’ attitudes towards mathematics and the outcomes in the subject, as well as the strong positive correlation between attitudes and achievement in Mathematics. Gkolia and Jervis (2006:199) report that “the attitude of students regarding their experience with Integrated Learning Systems (ILS) in Mathematics was overall positive but varied according to different aspects of software usage”. Female students held significantly more positive views about the use of an ILS than their male counterparts. According to Gal, Lin and Ying (2006:147), looking for characteristics which are the catalysers of low achievement, the common beliefs for some learners’ low achievement are blamed on their low socio-economic status, unwillingness to learn or personal disabilities. Iannone and Cockburn (2006:330) state that “the normative aspects of classroom interaction that are specific to Mathematics, originate in the teacher’s beliefs on what it means to learn, how students learn Mathematics and how they teach in order for students to learn Mathematics”. Kaasila, Hannula, Laine and Pehkonen (2006:386) put forward that the view of Mathematics is an important part of a person’s mathematical identity and consists of one’s knowledge, beliefs, conceptions, attitudes and emotions.

Van den Berg (2002:588) states that “the notion of teacher efficacy can be considered as a collection of beliefs, attitudes and emotions that basically guide the work of individuals and pertain not only to the achievements of students but also to the co-operation with colleagues and others involved in the school”.

Gibson and Dembo (1984:570) report that the beliefs of some teachers are that they possess the skills necessary to bring about positive changes in learners. Notwithstanding the affective constructs and their interrelatedness discussed in this chapter, Hannula, Pantziara, Waege and Schlöglmann (2009:31) list new constructs to the affective domain as:

- The kind of *personal meaning* that learners relate with mathematics education.
- *Emotional knowledge* of Mathematics teachers.
- *Humour* as a means to make Mathematics enjoyable.

2.10 CONCLUSION

The researcher concurs with most researchers who are of the opinion that to fully understand the influence of affect on the learning of Mathematics, it needs to be closely linked to the studies of cognition and *vice versa*. In debating the casual ordering of cognition and affect, the current and most sensible perspective are that the influences are bi-directional (Pintrich & Schunk, 2002:280). To pursue the argument of whether cognition precedes affect or *vice versa* may or may not aid the debate, but instead the focus should be shifted to an understanding of how, why and when cognition precedes and influences affect and how, why and when affect precedes and influences cognition. The notion of paradigmatic shifts from the traditional to the modern approaches in cognition begs the question of whether such shifts are discernible in the affective domain. The so-called *traditional* affective constructs are still relevant in modern day research on affect but their boundaries and interrelatedness with other contemporary affective constructs are now being explored and researched.

Hannula, *et al.* (2004: 108) states that the four affective constructs (attitude, beliefs, emotions and values) do not cover the whole field of affect. Terms such as motivation, feelings, moods, conceptions, interests, anxiety, *etc.*, can also be used as affect constructs or variables, especially within the new approaches to research on affect in mathematics education. From a mathematics perspective, cognition involves the creative and logical reasoning about problems in the physical and social worlds, where knowledge is constructed through the establishment of descriptive, numerical and symbolic relationships.

The earlier focus in this chapter on the development of mathematical competencies, both from within the cognitive and affective domains, can now be placed concomitantly with their influences on the learning of Mathematics (the so-called cognitive competencies and affective competencies). Understanding the development of mathematical knowledge from an affect orientation requires an understanding of an all-embracing perspective on what the nature of Mathematics entails. The arguments and statements presented by, *inter alia*, McLeod (1992:575), Gerretson and Golson (2005:139), Stone and Friedman (2002:199), Snyders (2008:236) Gal, Lin and Ying (2006:147), Iannone and Cockburn (2006:330), Kaiser (2006:395) and Evans and Zan (2006:46) support a coherent need when considering all factors that can influence the learning of Mathematics.

From a South African perspective, the National Curriculum acknowledges the roles of affect such as values and attitudes in the study of Mathematics (albeit as part of the so-called *hidden curriculum*). It is however still fundamentally and overtly focused on cognitive outcomes (general and specific aims). As long as there are no discernible efforts in integrating affective issues within a cognitive curriculum, research on affect may just become a disjointed, measurable entity having no or minimal impact on the learning of Mathematics and performances in Mathematics. Of paramount importance to this study is the development of mathematical competencies of learners and students when faced with the dilemma of the realities of learning. Considering the concerns that students may have about themselves, their mathematical tasks and their impact on the learning of Mathematics, may address the notion of being competent or becoming competent. A full exposition of student teachers' concerns is presented in Chapter 3.

CHAPTER 3

DEVELOPMENT AND CONCEPTUALISATION OF STUDENT TEACHER CONCERNS

3.1 INTRODUCTION

The induction of students into a teacher-training programme focuses on equipping them with knowledge and skills for future classroom practice. This process is developmental that ensures the acquisition of theories and practices from their (student teachers') first year of study to their final year. The developmental needs and concerns of student teachers need to be addressed to ensure that cohorts of competent and highly qualified teachers exit their training well prepared and confident to tackle the demands of the teaching profession. It is for this reason that these student teachers must be exposed to a myriad of meta-theoretical orientations that acknowledge a diversity of sources about knowledge and skills relating to teaching, learning and human development. Human development is a complex and multi-faceted phenomenon that can be interwoven with, *inter alia*, the domains involving cognition and affect. From an education perspective, to promote the development of student teachers an understanding of the various developmental domains, such as the physical, cognitive, affective, personal and social, need to be acquired. In order to fully comprehend the developmental stages inherent in some of these processes, one can allude to how student teachers process information, their levels of thinking skills and their innate sense of understanding. Theorists differ in their approach to the study of development but there is general consensus that students (as well as learners) develop at different rates and that development is an orderly process that takes place gradually. For instance, the traditional approach to teaching school mathematics is akin to learners' first being exposed to learning Mathematics through the use of manipulatives before setting out on an intuitive and practical

approach and finally being exposed to the rigour and formalisation of abstract Mathematics. This developmental process in traditional mathematics cognition is supported by the theory of Swiss psychologist Jean Piaget (1962). During the 1970s and 1980s, research on cognition tended to be analytical and linear owing to the influence of the Piagetian theory. The more holistic and interactive theory of Vygotsky led to more attention being paid to context and less to individualistic understanding of development (Eloff, 2001:63). Whereas Piaget claimed that all learners follow the same developmental stages independently of context, Vygotsky believed that cognitive development relates more to the culture and context in which it unfolds (cited in Eloff, 2001:64). The latter perspective provides the motivation for this thesis to consider the concerns that student teachers may have during field practicum, taking into consideration the different cultural and contextual settings of the classrooms and the life-worlds of their learners they have to teach (see Figure 2.2). The nature of developing concerns can be equated with developmental models that identify the stages of professional growth. One of the objectives of this study is to find out whether changes or development can be seen in the concerns of student teachers during field practicum (see *Research Question 2*), and to detect whether there are patterns in their concerns in the pre-post design format (measured over two sessions of field practice). The intention is to establish whether these patterns are similar to those found by other research studies on student teacher concerns. This chapter reports on the models of development that provides the theoretical constructs for the concerns theory initiated by Fuller (1969) and on work done by contemporary researchers on student teachers' concerns. A schema for this chapter is provided in Figure 3.1.

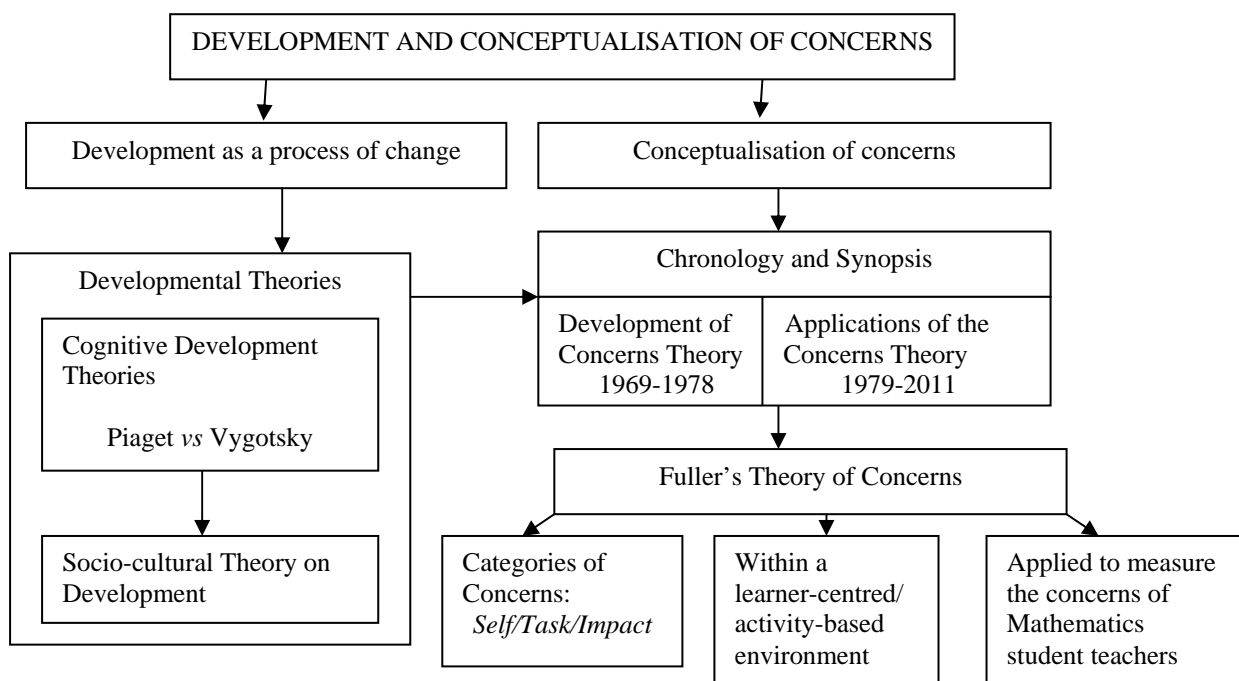


Figure 3.1: Schema for Chapter 3

3.2 CONCEPTUALISING DEVELOPMENT AS A PROCESS OF CHANGE

Development refers to the changes (growth) over time that follows an orderly pattern and enhances survival (Schunk, 2004:434). As a consequence, the term development is normally associated with change. This connotation may not necessarily be an implied positive orientation but can also allude to some degree of negativity associated with change⁵. Changes that occur during the developmental processes are indicative features of growth and maturation. According to Woolfolk (2010:26), “the term development is not always applied to all changes but rather to those that appear in orderly ways and remain for a reasonably long period of time”. The argument of whether development or change can be intrinsically ascribed to *nature* or *nurture* is an important consideration that cannot be ignored in any discourse on the causality or initiation pertaining to change. The historical foundations for development can be linked to the philosophical argumentations (as adapted from Schunk, 2004:440-442) around:

Nature versus Nurture: Does development depend more on heredity, environment or a combination?

Stability versus Change: Are developmental periods flexible?

Continuity versus Discontinuity: Does development occur continuously in small changes or do sudden, abrupt changes occur?

Passivity versus Activity: Do changes occur regardless of children’s actions or do children play an active role in their development?

Structure versus Function: Does development consist of a series of changes in cognitive structures or processes?

Notwithstanding these argumentations describing the causalities for development and for change, this study is predominantly qualitative in nature and considers the notion of individual perspectives and personal narratives that may add a deeper understanding of developmental changes (if any) in student teachers concerns over time during field practicum.

⁵ The polarities (+/-) of change can be implied by the reader in the context of textual interpretation and comprehension.

Numerous curricula revisions in South Africa may have contributed significantly to developing concerns that teachers (and prospective teachers) may have about implementing a curriculum that appears challenging in interpretation and in implementation (as noted by the 2000 and 2009 Review Committees, see Chapter 1). Questions need to be asked about teacher efficacy as well as student teacher efficacy within the classroom context when these concerns (about themselves, about their tasks and about their impact on learners' achievements and performances) become manifested as part of student teachers' and teachers' behaviour and conduct. As student teachers progress through their teacher-training levels of study, they must be content with concerns that relate to most of the dimensions involving teaching. For instance, the prospect of teaching a national mathematics curriculum whose focus on the learner-centred/activity-based approach (promoted by the CAPS curriculum and earlier post-1994 curricula) may be viewed as a daunting challenge by these prospective Mathematics teachers, since the new approach represents a highly significant break from the traditional mathematics methodology based on drill and memorisation to which they themselves may have been exposed to as learners. The learner-centred and activity-based approach of the South African National Curriculum draws on a broad philosophy of child-centred education, consistent with Piagetian and Vygotskian notions of the importance of active engagement (cited in Green, 2001:11). This thesis should not be seen as an attempt to give a complete overview of the so-called traditional as well as contemporary theories on development. In fact, some of these theories are examined partially and from a certain angle with a particular goal in mind in order to comprehend how concerns can be categorised in terms of stage or developmental theories.

3.2.1 Cognitive Development Theories: Piaget versus Vygotsky

Earlier definitions of cognitive development simply viewed it as changes in thinking. According to Mwamwenda (2004:84), "cognitive development is the development of a person's mental capacity to engage in thinking, reasoning, interpretation, understanding, knowledge acquisition, remembering, organising information, analysis and problem-solving". Modern theorists have taken into account a more embracing view by considering the influence of the affect on cognition.

For instance, Pintrich and Schunk (2002:20) state that cognitive theories emphasise more than just cognate development but also take into account the influences of beliefs and emotions on the mental processes. The change in emphasis in trying to define cognitive development reflects the old adage inherent in the debate in educational philosophy of *old* versus *new* or more appropriately *traditional* versus *modern* (contemporary). The following tabulation highlights this so significant debate and deliberations on the relevance of two cognitive theories that had such a dynamic impact on learning paradigms and instructional theories.

Table 3.1: Piagetian and Vygotskian views on Cognitive Development

Stage	Piagetian characteristics (Traditional view of cognition)	Stage	Vygotskian characteristics (Contemporary view of cognition)
Sensorimotor 0-2 years (infancy)	<ul style="list-style-type: none"> ■ Begins to make use of imitation, memory and thought. ■ Begins to recognise that objects do not cease to exist when they are hidden. ■ Moves from reflex action to goal-directed activity. 	Earlier years	<ul style="list-style-type: none"> ■ Can co-construct auto-narratives with teachers. Narratives structured differently in different cultures. ■ Learners' memory reflects views and feelings of teacher.
Pre-operational 2-7 years (early childhood)	<ul style="list-style-type: none"> ■ Gradually develops use of language and ability to think in symbolic form. ■ Able to think operations through logically in one direction. ■ Has difficulty seeing another person's point of view. 	Middle childhood	<ul style="list-style-type: none"> ■ Continues the early process of acquiring cognitive and social skills developed in his/her own culture. ■ Acquires competence in expressive and linguistic language (reading and writing). ■ Acquiring intellectual attitudes, dispositions and habits. ■ Begins to acquire scientific concepts.
Concrete operational 7-11 years (late childhood)	<ul style="list-style-type: none"> ■ Able to solve concrete (hands-on) problems in logical fashion. ■ Understands laws of conservation and is able to classify and seriate. ■ Understands reversibility. 	Adolescence	<ul style="list-style-type: none"> ■ Zone of proximal development (what learners can do independently and what they can do with assistance from others). ■ Value of co-operative learning settings. ■ Learners take responsibility for their own learning.
Formal operational 11-adult (adolescence and adulthood)	<ul style="list-style-type: none"> ■ Able to solve abstract problems in logical fashion. ■ Becomes more scientific in thinking. ■ Develops concerns about social issues, identity. 		

Acknowledgment: Piagetian characteristics - adapted from Woolfolk, A. (2010). Vygotskian characteristics- adapted from Eloff, I. (2001).

For the sake of brevity, only certain features of Vygotskian theory is highlighted in Table 3.1 and should by no means be considered as comprehensive to each of the stages. Vygotsky does not agree that there are discernible different stages of development but concurs that there is a definite progression across childhood and adolescence towards more complex and abstract thinking abilities (Green, 2001:83).

Piaget claims that that all learners follow the same developmental stages independent of context whereas Vygotsky believes that cognitive development relates more to the culture and the context in which it unfolds. According to Eloff (2001:64), this socio-cultural approach of Vygotsky refers mainly to thought, reasoning processes and language, all of which are conceptualised as formed in and through mediated social interactions.

3.2.2 Socio-cultural influences on Development

The paradigmatic shift in mathematics education toward more modern or contemporary theories of learning is the common conviction that knowledge cannot simply be transferred as ready-made from teacher to learner but has to be actively built up by every learner by taking cognisance of his/her societal and cultural settings. Socio-cultural influences from peers, families, cultures and communities play an important role in the student teachers' own development and the emerging concerns about their abilities to satisfy their own needs (self concerns) and that of their learners (learner concerns) may manifest themselves as a consequence of pressure.

Peer networking: These are large groups of peers with whom a learner may associate. The social interaction that takes place within these groups can influence achievement and performance in several ways (Pintrich & Schunk, 2002:384). Interactions and access with peer activities can result in so-called peer pressure (direct or indirect) to which learners within the groups have to adhere. The resultant consequence is a form of motivational socialisation (according to Pintrich & Schunk, 2002:400). At all stages of development but particularly during adolescence, the peer group can have a powerful influence on behaviour which can be positive, negative or as in most cases, mixed.

By considering the values held by the peer groups, these groups can usually have a strong influence on their members, however, very much depends on the participating individual (Pintrich & Schunk, 2002:401). Donald, Lazarus and Lolwana (2002:244) state that “owing to the specific inadequacies at family and school levels, these individuals tend to seek alternative sources of identity, status, acceptance and support in the peer groups”. The functionality of peer learning needs to be monitored to ensure the dynamic interactions of all members within such a group. Peer group pressure can cause the emergence or the amelioration of concerns either within the group or among individuals.

Families: Family involvement is vital in the child’s development and motivation and can become a predictor of achievement. Numerous factors can, however, influence the role of such involvement. One major consideration is the socio-economic status of the family (Pintrich & Schunk, 2002:389). Learners from poor socio-economic backgrounds tend to display lower achievement and motivation, and this may be as a result of lack of resources at home, parental set-up at home, inadequate space, nutritional problems, as well as an inadequate understanding of the value of schooling (Pintrich & Schunk, 2002:390). Like peer group pressure, family or parental pressure (be it covertly or overtly or a combination of both), can activate latent concerns within learners that if not appropriately addressed can lead to under-achievement or poor performance (Pintrich & Schunk, 2002:401).

To fully understand the evolutionary processes involved in socio-cultural developmental frameworks, a deeper appreciation of its origin needs to be acknowledged, starting with the need to create, invent or discover knowledge-related systems to a requirement to develop these systems further by adapting them to the scrutiny of an ever-increasing knowledge-based society. Most developmental theories focus on changes in biological, personality, psychological, behavioural, mental processes and/or other factors such as social and cultural. Developmental Theories can be classified into the following classes (adapted from Schunk, 2004:440-442):

Biological Theories: Individuals proceed through an invariant sequence of stages and that stage progression is largely determined by genetics.

Psychoanalytic Theories: Development represents a series of changes in personality brought about by satisfaction. Stages are qualitatively distinct.

Behavioural Theories: Development represents changes in behaviours produced by conditioning. Changes are continuous and quantitative.

Cognitive Theories: Development represents changes in mental structures or processes that occur as individuals take in information and mentally construct understandings.

Contextual Theories: Social and cultural factors affect development. Changes in persons or situations interact with and influence other changes.

In education, the developmental perspectives are shifted to the pedagogy and the didactical processes, namely, the propositions of teaching and learning models. To comprehend the developments around mathematics education, it goes without saying that an understanding of the development of mathematical knowledge needs to be integrated within such a discourse. The development of cognition and affect in mathematics education can be intimately linked to the didactical nature of teaching and learning (see McLeod, 1992: 591). The traditional perspective on knowledge is that it is passively received and processed without substantially altering its form, which in turn can be interpreted as limiting its development outside the traditional parameters of teaching and learning. In contrast, contemporary developmental theories and perspectives postulate that cognitive development involves the construction of knowledge as a function of the individual's experiences and belief systems. This tendency to focus on higher and abstract issues in education, such as theories and philosophical argumentations, seems to neglect the more fundamental issues that are important in the training of student teachers, namely addressing affect issues (as highlighted in Chapter 2) and the manifestation of developing concerns about the abilities to become competent teachers.

Table 3.1 refers to the cognitive development in relation to the earlier stages of human development with the discussions (in paragraph 3.2.2) highlighting the influences of social and cultural factors on such development. Since human development is an ongoing process, children develop to the stage of early adulthood where decisions have to be made as to the direction in which they want their lives to unfold, in particular, in their career choices they make. Within the teaching profession, student teachers and even teachers have to adopt some form of professional identity that is linked to this chosen career.

Gilmore, Hurst and Maher (2009:2) define the development of a professional identity in terms of:

- Reconciling prior beliefs with reform teaching.
- Locating an identity within a community of practice.
- Managing emotional aspects of identity formation.
- Integrating experiences and theory.
- Developing a sense of self-confidence.

One comprehensive view of teacher identity development, conceptualised over four decades ago, was based on the work of the late Frances Fuller. The theoretical framework initiated by Fuller in 1969, proposed that the developmental stages of teachers could be studied and expressed in terms of their concerns, that is, teachers underwent a series of developmental stages characterised by unique concerns. According to Buhendwa (1996:5), teachers' developmental stages could be equated with developmental patterns of teachers' concerns. Of paramount importance to this study, were how student teachers concerns could be conceptualised and how these concerns developed or changed within the frameworks provided by developmental theories (see paragraph 3.4).

3.3 EARLY RESEARCH ON CONCERNS

The development of teachers is a process that evolves in stages. There are a variety of developmental theories (see paragraph 3.2.2) that can provide the theoretical constructs to explain such development. The placement of concerns in a developmental hierarchy is noted in this paragraph by several researchers (see paragraphs 3.3.1 and 3.3.2). The term *concern* in this study is not used synonymously with the affective constructs such as feelings of uneasiness, apprehension, tension or anxiety. Rather, an acceptable definition that fits within the purview of the study is the one provided by George (1978:37) during the earlier years of research on concerns that states that a person is considered to be "concerned" about something if he or she thinks about it frequently and would like to do something about it

personally. Synonymous to this definition, is the one given by Knowles (1981:49) who regards concerns as a composite of feelings, thoughts and considerations given to a particular issue or challenge.

3.3.1 Chronology on the Development of the Concerns Theory and Associated Research

Review of literature on earlier research on student teacher concerns (pre-1969), revealed only two studies of interest, namely, one undertaken by Travers, Rabinowitz and Nemovicher (1952) that focused on female elementary major student teachers (cited by Reed, 1995:48). The usefulness of the Travis, *et al.* study was queried on the basis of the small number of test items used, namely three. The other study was undertaken by Thompson (1963) who conducted a pre-post concerns investigation. However, he interpreted concerns in terms of anxieties experienced by student teachers during their student teaching experiences (cited by Reed, 1995:48). Of particular interest to the discourse on concerns is the chronology on research done by Fuller and some of her associates on the concerns of pre-service student teachers and in-service teachers, as well as contemporary contributions to the fields of teacher development and the concerns theory. By no means is the chronological discourse in this thesis regarded as being inclusive of all related research undertaken on teacher development and concerns theory. Rather, the focus of the literature review pertains to those research articles that can aid the investigation of this thesis and provide some form of theoretical basis for the quantitative measurement of student teacher concerns (as part of the empirical study).

1967

Fuller (1967:1-2) related a six-stage sequence of teacher concerns in a paper entitled *Behavioral Science Foundation for Elementary Education: Course Content Ordered by Empirically Derived Concerns Sequence of Prospective Teachers*. The paper highlighted appropriately-related course content for each concern sequence on a chart that included:

- Covert concerns of prospective teachers.
- Developmental tasks associated with each concern.
- Sample educational psychology course content associated with each concern.

According to Fuller (1967:1), a sequence of concerns was revealed which student teachers appeared to feel from the beginning of observation to the end of the student teaching experience. The six-stage sequence of concerns (Fuller, 1967:3-5) dealt with:

Stage 1: Where do I stand?

Stage 2: How adequate am I?

Stage 3: Why do they do that?

Stage 4: How am I doing?

Stage 5: How are they (learners) doing?

Stage 6: How does what I am doing influence them (class)?

Further research was undertaken by Fuller, Pilgrim and Freeland (1967), and they reported on the experiences of student teachers who took part in a project designed to find ways to prepare student teachers to be ready to learn how to teach at the beginning of their student teaching period instead of at the end. According to Fuller, Pilgrim and Freeland (1967:1-2), the project sought to devise ways of using group therapy techniques to meet the concerns of prospective teachers and help them cope with their personal development tasks.

1969

Based on earlier research, Fuller became the pioneer in the field of concerns theory and initially proposed a three-phase model of teacher development. The model was developed based on interviews with 14 student teachers, written statements from 29 student teachers, and a comparison of the concerns of these student teachers to those of experienced teachers expressed in previous studies.

The research undertaken by Fuller in 1969 was to become a pioneering study on how to conceptualise the concerns of teachers and was first published in the *American Education Research Journal*, and entitled *Concerns of Teachers: A Developmental Conceptualization* (Fuller (1969); also see Reed, 1995:51).

The *first phase* of the model was referred to as the *pre-teaching phase* as it dealt with no or few concerns that student teachers might have had about teaching. The motivation for this consideration was that according to Fuller (1969:218), the ideas that student teachers had came from their experience as students themselves, and any concerns they had were "amorphous and vague" (Fuller, 1969:219). Quite simply put, these students were not really sure what to be concerned about at this pre-teaching stage. The non-teaching concerns focused on statements containing information or concerns unrelated to teaching. These concerns were basically personal in nature and indicated that the student teachers had no concerns about teaching. Included in these statements were the concerns about meeting programme/course requirements, obtaining good grades, availability of teaching positions and salary scales (cited in Reed, 1995:57).

Phase two dealt with the early stages of teaching and included self-survival statements that were categorised as *concerns about self-benefit*. These concerns consisted of covert concerns and overt concerns. Student teachers in this stage were covertly concerned with how much support they would have in the school environment, getting along with other school personnel and presenting themselves as professionals. According to Fuller (1969:220), these concerns were classified as *covert* because they were only expressed "during confidential contacts" and not stated in written form or "routine interviews". The *overt* concerns in this stage focused mainly on "adequacy in the classroom" (Fuller, 1969:220). These concerns were self-directed. Student teachers were concerned with their own abilities. They worried about knowing the subject matter, anticipating problems, being allowed to fail, correcting when they do fail, and being able to cope with being evaluated. Fuller (1969:221) states that "the intensity of concern with self-adequacy (and evaluation) was so great that it was easily underestimated". Student teachers were expected to worry about class management and visits by their supervisors. However, Fuller found that student teachers were often even more concerned with these areas than their supervisors.

The *third phase* dealt with the needs of learners (*concerns about learner-benefits*). In this phase, concerns shifted away from the self-benefit to the learner-benefit. Student teachers now measured their success by learner achievement and gain, rather than by being evaluated by a supervisor. Fuller (1969:222) states that “student teachers in this stage were more concerned about their abilities to understand learners’ capacities, specify objectives for them, assess learner gains and partial out their contributions to learner difficulties and gain, and to evaluate themselves in terms of learner gain”.

In November 1969 Fuller and Case presented a manual entitled *Concerns of Teachers. A manual for Teacher Teachers: Increasing Teacher Satisfaction with Professional Preparation by Considering Teachers’ Concerns when Planning Pre-service and In-service Education*. The manual reviewed research done on teacher concerns. According to Fuller and Case (1969:1), a developmental model of teacher concerns was proposed based on convergence in the research findings. The developmental model also provided the rationale for a system for scoring concerns. The manual focused on four areas, namely (Fuller & Case, 1969:1-2):

- Firstly, the research on which the conceptualisation of teacher concerns was based was summarized and questions for further research were posed.
- Secondly, teacher concerns were informally described.
- The third area involved the description of the instrument used to measure what teachers were concerned about.
- Fourthly, the listing of other materials which were available from the Research and Development Center for Teacher Education.

1970

An open-ended questionnaire was developed by Fuller and Case in 1970, and administered to more than 1500 pre-service and in-service teachers. The questionnaire was entitled *The Teacher Concerns Statement*.

The instructions for this instrument were straightforward and based on the underlying assumption that the best way to find out what teachers were concerned about was to ask a frank question: *When you think of your teaching, what are you concerned about?* According to Fuller and Parsons (1972:2), a six-category coding system was developed and revised by Fuller and Case.

1972

Fuller and Parsons (1972) presented a paper *Current Research on the Concerns of Teachers* at the Annual Meeting of the American Educational Research Association in April 1972. The purpose of the paper was to familiarise the education community with the research on teacher concerns that had taken place since the publication of the article *Concerns of Teachers: A Developmental Conceptualization* (see Fuller (1969)). In the paper *Current Research on the Concerns of Teachers*, Fuller provided the rationale and evidence for dividing the concerns voiced by the teachers into two basic types. According to Fuller and Parsons (1972:1), labels for these two types were conceived as opposite poles along a continuum of teacher concerns: Concerns about self-benefit characterised by self-survival statements, and Concerns about learner-benefit characterised by concerns about the needs of learners. The focus of the paper was two-fold. The first was a report on the reliability of information for the Teacher Concerns Statement. The second was primarily concerned with establishing the bipolar nature of the self-benefit to learner-benefit continuum of teacher concerns. Research on another instrument was undertaken by Cohen, Mirels and Schwebel (1972:6-10) who tested an objective instrument containing 122 items. The work was along the lines of Fuller's research and focused on the hierarchies of concerns. However their results were questionable for not meeting the standard criterion for factor analysis.

1973

According to Akuffo (2005:46), the pioneering work of Fuller served as the basis for the development of the Concerns-Based Adoption Model (CBAM) developed by Hall, Wallace and Dossett in 1973, including the Stages of Concerns (SoC) about the innovation dimension.

While the work of Fuller focused on the concerns of teachers as they teach, the work of Hall, Wallace, and Dossett focused on the adoption process by which an education institution adopts an innovation and views an adoption as a developmental process.

1974

In 1974, in a paper entitled *Concerns of Teachers: Recent Research on Two Assessment Instruments*, Parsons and Fuller (1974:1-2) state that two branches of research have been pursued and that the differences between the two branches were in the type of assessment instruments used. The first branch was the use of an open-ended and a free-response instrument called the Teacher Concerns Statement and was content analysed using a variety of scoring systems. The first three categories on the Teacher Concerns Statement dealt with self-benefit or self-survival concerns, such as concerns about role, concerns about adequacy and concerns about being liked or liking.

The remaining three categories dealt with learner-benefit concerns, such as concerns about teaching, concerns about learner needs and concerns about educational improvement. According to Parsons and Fuller (1974:3), self-survival concerns were hypothesised to be related to inexperience while learner-benefit concerns related to experience in teaching. The second branch of research pursued was deeply rooted in the frustrations in working with the Teacher Concerns Statement, especially involving coder agreement and stability deficiencies (Parsons & Fuller, 1974:7). A Teacher Concerns Checklist (TCCL) was designed and using information gleaned from factor analysis of the Teacher Concern Statement, items were constructed for the TCCL. A second version of the checklist was designed and named the TCCL-B. The instruction for this instrument was the same as for the Teacher Concerns Statement: *When you think of your teaching, what are you concerned about?* Since the TCCL-B was not an open-ended instrument, the respondents now had to place a tick under one of the five categories representing the degree of the concern felt:

Degree of Concern				
Not concerned at all	Slightly concerned	Moderately concerned	Very concerned	Extremely concerned

Parsons and Fuller (1974:8) posit that the TCCL-B was a vast improvement on the Teacher Concerns Statement since coder agreement and stability deficiencies were no longer an issue as TCCL-B was machine-scored. An added advantage of the TCCL-B over the Teacher Concerns Statement was its greater tendency towards normality of distribution as none of the category scores for the Teacher Concerns Statement distributed normally.

A paper entitled *Concerns of teachers: research and reconceptualization* (Fuller, Parsons & Watkins (1974)) was presented in this year too. Fuller, Parsons and Watkins (1974:21-23) state that “the concerns theory could be conceptualised developmentally and that the distinctness of the stages was identified by considering the range of teachers’ concerns”. [See Cho and Kwon (2004:190) reference to stage theories of concerns. Stage theories can be contrasted with continuous developmental theories which posit that development is an incremental process that involves gradual and ongoing changes throughout the life span, with behaviour in the earlier stages of development providing the basis of skills and abilities required for the next stages.]

1975

In 1975, after collecting and analysing more data, Fuller and Brown re-examined the 1969 model for teacher development and identified three areas of teacher concerns: survival concerns, teaching situation concerns, and learner concerns. Fuller and Brown presented a three stage model (*herewith referred to as the Fuller-Brown model of teacher development*) that indicated a developmental sequence of concerns from self concerns → task concerns → impact concerns. It is the contention of the researcher that the Fuller-Brown model (1975) is an example of a stage theory since development involves distinct and separate stages (albeit hierarchical in nature) with different kinds of concerns (and behaviour) occurring in each stage. Fuller and Brown (1975:38) state that teachers in different stages of their careers were more focused on certain concerns. In stage one, the pre-service teachers began to have "early concerns about survival" (Fuller & Brown, 1975:38). *Self (survival) concerns* were "concerns about one's adequacy and survival as a teacher" (Fuller & Brown, 1975:37). Student teachers' first contact with teaching brought about concerns over class control, mastery of content and evaluation. They also had doubts about their own abilities to teach.

They began to move past abstract concerns about teaching to focus more on themselves as teachers. Consequently, teaching situation concerns were “added to self-survival concerns” as teachers progressed into the second stage (Fuller & Brown, 1975:39). This stage dealt with concerns about *teaching* not just surviving. Teachers were now concerned about the “limitations and frustrations of the teaching situation and about the varied demands made on them” (Fuller & Brown, 1975:39). They no longer worried about knowledge of content but about teaching that content to others. Although their concerns had moved from potential difficulties to actually perceived difficulties, teachers in the second stage were still focused on themselves. Some of the concerns focused on controlling the class, being liked by learners and meeting with the supervisor approval. *Teaching situation concerns* (referred to as *task concerns*) included concerns about the number of learners, time constraints, lack of materials and other situational factors. In the third stage, the focus shifted to learner concerns.

Learner concerns were “concerns about recognising the social and emotional needs of learners” (Fuller & Brown, 1975:37), as well as concerns about matching curriculum to learners, individualising instruction and being fair to learners. Having mastered content and teaching knowledge and figured out the teaching situation, teachers became concerned with connecting the subject to the learners and with meeting the needs of their learners. Teachers also started moving past the subject-oriented needs of learners and become concerned about the emotional needs of learners (referred to as *impact concerns*). It is important to note that the Fuller-Brown model focused on the *concerns* of teachers rather than what they had accomplished. A teacher might have had great concerns about learners’ needs and tried to meet those needs but failed. This failure was not an issue in the theory, only the fact that the teacher had actually been concerned with attempting to benefit the learner.

Other research undertaken was that of Clark and Mahood (1975) on the concerns and the emotional maturity of prospective teachers. Their findings revealed that there were incongruencies between the concerns of undergraduate students and those current educational programmes that were directed towards higher and more abstract theoretical levels. To them it would seem that students were too involved with lower level concerns to appreciate those based on higher levels (Clark & Mahood, 1975:13). Noted too, was that Clark and Mahood (1975:5) adapted the Teacher Concerns Statement questionnaire for their study.

Instead of asking respondents to write an essay on their concerns, they were merely asked to list their concerns.

1978

Following the earlier work of Fuller, George (1978) constructed the Teacher Concerns Questionnaire (TCQ) to obtain measures of the three areas of teacher concerns that had presented evidence that partially supported Fuller's hypothesised developmental hierarchy of concerns. The TCQ consisted of 15 items with five items on each of the self, task and impact sub-scales. Reliability and validity for the TCQ was reported by George (1978:25-29). The TCQ has been adapted in this study and modified as the Student Concerns Questionnaire (SCQ) [see Appendix C].

3.3.2 Chronology on the Applications of the Concerns Theory and Associated Research

The focus of this chronological discourse now shifts to the application, modification and the adaptation of the earlier research models and theories undertaken by Fuller and her associates to further investigate other related areas of development and concerns.

1979

A study conducted by Cunningham and Blankenship (1979) using 96 non-black female undergraduate primary school teachers, investigated the relationship between age, curriculum speciality and teacher concerns using the TCCL-B instrument. They found that teachers had significantly more self concerns when viewing themselves as teachers in general as opposed to their teaching speciality.

1982

According to the Centre for Education Research and Innovation (1982:18), Feiman and Floden also expanded on the Fuller model and suggested that teachers' areas of concerns could be seen as follows:

Early Phase:

- Concerns about self.

Middle Phase:

- Concerns about professional expectations.
- Concerns about staff, learners, parent acceptance.
- Concerns about professional adequacy: subject matter and class management.
- Concerns about relationships within the school.

Late Phase:

- Concerns about learners' learning and what is being taught.
- Concerns about relevance of subject matter being taught.
- Concerns about teachers' contribution towards change.

1983

Bowers, Eicher and Sacks (1983:19-24) developed an instrument called the Student Teacher Concerns (STC) that contained 50 items designed to measure concerns about the roles of the teachers and the relations to authority figures. They found that student teachers experienced anxiety prior to student teaching and that little was done to assuage it (Reed, 1995:71). A weakness of Bower and his associates' research was that their work seemed to focus only on the self concerns of student teachers (*researcher's contention*).

1985

Reeves and Kazelskis (1985:270) posited that the results of their study on the concerns of pre-service and in-service teachers were in general agreement with those reported by George (1978). In particular:

- In-service and pre-service teachers expressed greater concern for impact than for either self- or task- concerns.
- In-service teachers expressed only moderate levels of self- and task-concerns with little important difference between the levels of these two concerns.
- Pre-service teachers expressed moderate levels of concerns for task but significantly higher levels of concerns for self than for task.
- The primary difference between the in-service and pre-service groups was the higher concern for self expressed by the pre-service teachers.

According to Reeves and Kazelskis (1985:270), their results partially supported the teacher concerns theory. However, their finding that the impact concerns scores were highest for both in-service and pre-service teachers presented a dilemma. They questioned whether there was a problem with the concerns theory or in the measurement of the impact concerns' subscale using the TCQ, which remained to be determined. Theoretically, concern for impact should be lower for the pre-service group and should become higher only after concerns for self and task had been resolved.

1988

O'Sullivan and Zelinski (1988) presented a paper at the Annual Meeting of the National Association for Research in Science Teaching entitled *Development of a Stages of Concerns Questionnaire for Pre-service Teachers (SoCQ)*. The study was undertaken to examine the validity and reliability of a modified version of the SoCQ intended for use with pre-service teachers in undergraduate and fifth-year teacher preparation programmes. They made recommendations for further refinements.

1989

Of notable importance to this study was the following research undertaken by Pigge and Marso (1989) to investigate whether or not teacher-training had a predictable impact on the affective attributes of student teachers. A study of this nature could find congruency with Chapter 2, which addresses the issue of how affective constructs impact on the learning of Mathematics. According to Pigge and Marso (1989:2), measures of attitudes, anxieties, confidences and concerns were administered to a sample of prospective teachers on commencement of training and again at the completion of student training. They found that as these prospective teachers progressed through their teacher-training, they became less concerned about their self-survival as a teacher but more aware of the complex demands of the teaching profession (task concerns), became less anxious about becoming teachers and became more assured about their decisions to become teachers. The findings linked to the concerns measures were reported to be generally consistent with Fuller's stages of concerns' teacher development model (Pigge & Marso, 1989:10). In addition, a study conducted by Maxie (1989) described and analysed the student teaching experience and its role in the development of a select group of elementary-level student teachers.

The research proposed to determine, qualitatively, the concerns of student teachers; to determine change in student teachers' concerns and to describe and analyse the role of the student teaching experience in terms of factors perceived to influence student teachers' concerns and teacher development. The theoretical framework used for describing teachers' concerns was Fuller's (1969) developmental model of concerns.

1993

According to Hodge and Akuffo (2007:400), the concerns theory of Fuller (1969) which posited that teachers have different concerns at different phases of their professional development, was counter-argued by McBride in 1993. McBride argues that his findings were not consistent with Fuller's predications and declares that even though three distinct stages of concerns were identified and defined, some overlapping was expected, in the sense that human characteristics were variable and attempts to classify them into separate and

distinct stages may not always have been successful. In addition, Hodge and Akuffo (2007: 400) state that “the research work undertaken by Fuller and her associates contributed significantly to the conceptualisation of the Concerns-Based Adoption Model (CBAM)”. While Fuller focused directly on teachers’ concerns as they taught, the work of Hall, Wallace and Dossett (1973) focused on the implementation of innovative practices within educational settings. In accordance with the CBAM, as teachers encounter innovations they pass through seven stages of concern. These stages were: awareness, informational, personal, management, consequence, collaboration and refocusing.

1995

According to Reed (1995:5), research studies into the professional growth of student teachers in the classroom during field practicum, at different stages of student teaching experiences in their pre-service education and training, were not all that prevalent in the literature, since relatively few studies had been conducted outside the United States of America (USA). Research undertaken by Reed (1995) on the teacher-training programme at the Perseverance College of Education in Kimberley, South Africa, noted the inadequacy of the professional programme in not addressing learner-benefit concerns in the classroom (Reed, 1995:1). He concluded that the programme itself might not be preparing prospective teachers for the high level demands in addressing the needs of learners. He noted that research was long overdue in designing teacher education programmes that would attempt to address the concerns of student teachers [synonymous with two of the objectives of this study (see *Research Question 2* and *Research Question 4*)]. Reed (1995:297) used Fuller’s developmental model of concerns as a basis for data interpretation regarding the professional development of student teachers. It was initially assumed that the sample of student teachers was perceived to be primarily consumed with low-level didactical self-survival concerns. However, the results revealed that these didactical concerns could not be conceptualised into a sequence of developmental stages (Reed, 1995:298), that is, the student teachers had not developed professionally from low-level self-survival concerns to high-level learner-benefit concerns (Reed, 1995:297). Student teachers entered the field practicum programme being primarily concerned about impact-related items and emerged from the programme remaining impact-concerned (Reed, 1995:224).

2003

Conway and Clark (2003:465) re-examined Fuller's concerns-based model of teacher development by investigating teacher development during a two-semester teaching internship programme. By examining patterns of evolving concerns and aspirations, their results supported and extended Fuller's developmental model. Interns' concerns shifted outward from self, to tasks, to learners, as well as inward, from those about personal capacity to manage their classrooms to concerns about their personal capacity to grow as teachers and as people.

2004

Ralph (2004:411) examined student teacher interns' and their classroom co-operating teachers' concerns about the extension of the field practicum both before and after their completion of the 16-week programme. Respondents completed pre- and post-internship surveys, identifying their initial concerns about the internship and the subsequent alleviation of these concerns (or the emergence of other concerns). All the respondents reported that some of their initial apprehensions were alleviated by the end of the internship but nearly all of them stated that some concerns remained and that some new concerns had emerged. The student teacher interns all reported having developed specific professional strengths during the internship. Evidence supporting some of Fuller and Brown's (1975) three-stage concern theory was found. According to Ralph (2004:411), "implications of these findings were made with regard to enhancing the effectiveness of the extended practicum programmes". Of importance too was the study undertaken by Christou, Eliophotou-Menon and Philippou (2004:157) who had identified and examined the concerns of primary school teachers in Cyprus about the implementation of a new mathematics curriculum and the use of new mathematics textbooks. The adaptation of the Stages of Concern Questionnaire (SoCQ) based on the Concerns-Based Adoption Model (CBAM) was administered to a representative sample of teachers. According to their findings, the concerns of teachers largely focused on the task stage of the CBAM model. Furthermore, "there were significant differences in the concerns of teachers across years of teaching experience but not across years of implementation" (Christou, Eliophotou-Menon & Philippou, 2004:157).

In a research investigation on teaching concerns, Lotter (2004:29) claims that her study developed a picture of how pre-service Science teachers' instructional concerns changed during a year-long science methods programme, spanning classroom observations through to student teaching. According to Lotter (2004:35), the pre-service teachers' reflections emphasised self concerns over learner concerns as predicted by Fuller (1969). She also provided a tabulation of concerns items as per five teaching concerns categories (see Appendix H).

2005

Akuffo (2005:10) used the concerns theory of Fuller (1969) that was later modified by McBride in 1993 as the framework for his study. One of the purposes of his study was to determine whether or not Adapted Physical Education (APE) teachers had any job-related concerns. According to Akuffo (2005: 10), teachers had concerns that were job-related. His results revealed that APE teachers' concerns were consistently similar and defined in terms of the urban school context in which they carried out their roles and responsibilities (Akuffo, 2005:255).

2007

An investigative study was undertaken by Hodge and Akuffo (2007) to determine whether or not Adapted Physical Education (APE) teachers had job-related concerns associated with teaching learners with disabilities in an urban public school district. Their findings indicated that the teachers had job-related concerns explainable within the tenets of the concerns theory. They also had concerns not situated within concerns theory that were unique to their itinerant status (Hodge & Akuffo, 2007:410-411).

2008

The study conducted by De La Torre and Casanova (2008) was to analyse the relationship between the respondents' conditions (prospective or in-service), their personal and general

expectations of informed efficacy and how they perceived various teaching concerns (self, task and impact) described by Fuller (1969). The findings revealed that student teachers with the highest sense of personal efficacy were most concerned about self-survival as teachers, while in-service teachers that had a low sense of personal and general efficacy were more concerned about the academic, social and emotional impact of teaching (De La Torre & Casanova, 2008:179). In addition, a study undertaken by Parkison (2008), focused on the field placement aspect within teacher education, and he regarded it as a topic of interest for all pre-service student teacher programmes. Parkison (2008:29) posits that by conducting a focused study of the current pedagogical methods being utilised in a Middle Level Instruction and Curriculum course, it was possible to evaluate treatment effect on the enhancement of student teacher self-efficacy and dispositional preparation. Utilising a Multivariate Analysis of Variance (MANOVA) experimental design with repeated measures, treatment effect on student teacher self-efficacy was evaluated based on Fuller's stages of concerns. The findings suggested a more data-driven discussion of the appropriate pedagogical methodology for the development of student teachers' attitudinal orientation and dispositions.

2009

The results of the study conducted by Gilmore, Hurst and Maher (2009) somewhat supported the developmental trajectory of concerns proposed by the Fuller-Brown model (1975). In particular, the less-experienced teacher (LET) participants were more likely to describe their identity as a teacher in terms of personality characteristics which is consistent with the identity crisis that occurs during the survival stage (Gilmore, Hurst & Maher, 2009:18). Experienced teacher (ET) participants recounted more frequently their ability to adjust their teaching based on learners' cultural and academic background, which was consistent with Fuller-Brown's claim that teachers in the task stage were more knowledgeable about the tools to use in a given situation. Given that some of the LET participants (such as the participant with minimal prior teaching experience – identified as being able to adjust to the pace and depth of instruction to meet learners' needs) in this sample progressed to these concerns perhaps faster than predicted by Fuller and Brown. Further research should investigate if/how co-teaching experiences could assist student teachers in minimising classroom management concerns and allow them instead to focus on facilitating student

investigation (Gilmore, Hurst & Maher, 2009:18). Also in 2009, Chang (2009:19-25) examined the concerns of teacher candidates (student teachers) in an early field experience. Results showed that teacher candidates ranked impact as the highest concern, self as the second concern, and task as the least concern. The ranking of concerns remained the same across different developmental points of the field experience. Accordingly, the study suggested that concerns were related to the nature of the field experience but not to the developmental points of the field experience (Chang, 2009:19).

2010

Reflectivity is an important component of teacher education. According to Ballard and McBride (2010:58), little information existed that specifically addressed when changes in reflectivity might occur. One of their study focuses was to apply Van Manen's model to examine levels of, and changes in, reflectivity. A connection was drawn between Fuller's stages of concern and the levels in Van Manen's model. For instance, the shifts in reflectivity observed in this study closely paralleled Fuller's Developmental Concerns Theory that consisted of three hierarchical stages of: self, task and impact. Van Manen's level one, for example, was similar to Fuller's self stage. At Fuller's task stage and Van Manen's practical action stage (level two), needs were being addressed and educational consequences were being considered which now became the focused issue. Fuller's final stage, impact, corresponded to Van Manen's critical reflection. In both models, teachers were asking whether the material was relevant and how achievement levels might be increased. Ballard and McBride (2010:58) state that the findings of their study were similar to Fuller's Developmental Concerns Theory and supported assertions that students could increase their reflective thinking. Berg and Miksza (2010:39), investigated the status and development of junior level pre-service music teachers' concerns using the Fuller-Brown teacher concerns model, and found an overall emphasis on task concerns. To them it appeared that the participants were more concerned with pedagogical execution than with their personal characteristics or learner impact.

2011

Kim, Cho and Svinicki (2011:13) explored how college faculty characteristics were related to their teaching concerns based on Fuller's model of teacher concerns. They found that impact concerns were the highest among the three categories of teaching concerns regardless of teaching experience. Aside from teaching experience, the following were found to be associated with faculty concerns: teacher efficacy, intrinsic motivation to teach and pedagogical knowledge. An important study was undertaken by Goh and Matthews (2011, 92-103) on the concerns of student teachers during field practicum. Eighteen derived concerns were identified and placed into four main categories:

- Classroom management and learner discipline.
- Institutional and personal adjustment.
- Classroom teaching
- Learning by learners.

Specific comments were elicited to provide citations that represented their (student teachers') concerns. The study was intended to focus attention to the underlying reasons given by student teachers for their concerns before and during the practicum in order to integrate areas of concern into future management and development of teacher education. According to Goh and Matthews (2011:92), "the value of the study was in the pursuit of using student teachers' own capacity to self-assess and appraise their circumstances as a research area in teaching". It was also useful to know how the understanding of learning to teach could be enriched through self-awareness of the circumstances surrounding them as student teachers.

3.3.3 Synopsis of the Concerns Theory and Associated Research

In sum, the review of the related literature on the chronology of teacher development models and concerns theory applications from the pioneering years of 1969 onwards, revealed the following:

- As soon as student teachers gained classroom experience there was a notable decline of self concerns.
- That concerns about self, concerns about task and concerns about impact were separate constructs (mimicking the features of stage theories).
- Task concerns and impact concerns had not seemed to vary with experience.
- Before student teaching, student teachers experienced the greatest concerns about classroom management and relations with teachers.
- Student teachers were highly concerned about their impact on learners and desired their learners to take a liking to them.
- Applications of teacher development models, including the concerns theory, were at most investigative studies related to teacher and professional identity, professional growth and development. Few were subject-specific oriented.
- The question was posed whether the Teacher Concerns Statement, the TCQ or even the TCCL-B were adequate instruments to measure a concerns item that was unique to each subject or phenomenon under investigation.

Since the initial work conducted by Fuller in 1969, it was noted that numerous research studies had been (and probably will still be) undertaken using the Fuller paradigm to investigate or seek to establish:

- hierarchies of differences in concerns at different levels of the teaching experience;
- studies to investigate influences on (student) teacher concerns; and
- an understanding of the influences of concerns on other variables.

3.4 FULLER'S THEORY OF CONCERNS

To establish Fuller's Theory of Concerns within the confines of a developmental framework, the descriptive behaviours within the stages can allude to the type of development inherent in the concerns theory. It was obvious from Fuller's stages of concerns that the development of concerns from one phase (or stage) to another was not automatically continuous but was characterised by qualitative differences in behaviour in each of the stages. Fuller postulated that student teachers experienced a developmental sequence of concerns in stages as they progressed through their teacher-training programme from *survival concerns* to *task concerns* to *impact concerns*. According to the theory, student teachers (or teachers) progressed through these three stages as they developed professionally. In answering the question of how student teachers (or teachers) developed through this sequence of phases, Fuller suggested that Maslow's hierarchy of needs was the key to this question (Gage & Berliner, 1988:336-338). Early concerns were linked to security needs and later concerns to task-oriented or self-actualisation needs, which would only have come about if security needs had been satisfied. Feiman and Floden (1980:128) support this contention, stating that until survival concerns have been resolved then only will task and impact concerns emerge.

These phases addressed what the student teachers (or teachers) were concerned about, and theoretically were developmentally related. According to George (1978:1), "only after both self concerns and task concerns have been dealt with successfully, do concerns about impact begin to predominate". To Fuller (1969:222), student teachers experienced concerns about survival (low-level concern) because of their first contact with teaching. Fuller believed that the main objective was to move student teachers from concerns about themselves toward concerns about their learners (middle-level concern). Fuller, Parsons and Watkins (1974:36) maintain that "student teachers would have attained maturity in their development when they experienced impact concerns (high-level concern)". A pre-post test study undertaken by Reed (1995:224-226) found no such developmental progression along the concerns continuum when compared with that of the Fuller theory. He reported that student teachers entered the field practicum programme being primarily concerned about impact-related items and emerged from the programme remaining impact-concerned.

The empirical investigative part of this study utilised the Fuller-Brown model of teacher development (1975), presented as a three-stage model that indicated a developmental sequence of concerns from self concerns → task concerns → impact concerns (also referred to as the concerns' sub-scales). Fuller's research on concerns (Fuller (1969), Fuller & Brown (1975)) and the TCQ of George (1978)) provided a theoretical basis for the study of the concerns of student teachers during field practicum, as well as for the utilisation of the SCQ respectively. Concerns experienced by student teachers in their field practicum have been reported in other studies to indicate that it was not an isolated phenomenon. Some of these studies were conducted outside the concerns categories of Fuller. One such study by Morton, Vesco, Williams and Awender (1997:69) posit that "differential reactions to concerns were likely to be a function of variables such as personality, sex and culture". Thus male and female student teachers might respond differently to the specific concerns of the teaching experience. Similarly, student teachers in one country might differ in perceived concerns from student teachers in another country (p. 70). Teacher education programmes need to take into account the myriad forms of concerns that student teachers might have or that might become manifested during institutional learning and field training, especially in the field of Mathematics, as it is one of the few learning areas or subjects that have the potential of causing concerns about the abilities to teach and learn Mathematics. Concerns need to be identified and addressed in order for student teachers to become motivated and become personally committed to their teaching and be able to cope with the realities of the classroom.

3.5 CATEGORIES OF CONCERNS

According to Clark and Mahood (1975:1-3), the initial concerns model (Fuller, 1969) was subsequently developed into three stages when Fuller and Brown (1975) proposed a theory of hierarchical levels of concerns (Fuller, Parsons & Watkins, 1974:38):

- *Concerns about Self:* dealt with teachers being preoccupied with their own inadequacies as teachers.
- *Concerns about Task:* when teachers concentrated on performance and concerns by focusing on the teaching task.

- *Concerns about Impact*: when teachers either settled into routines, resisting change or they become concerned about their impact on the learners and were also opened to feedback on themselves.

The categorisation within the concerns phases (see Fuller, Parsons & Watkins, 1974:6-7; Clark & Mahood, 1975:6-9) was based on the descriptors related to the attributes inherent in each of the phases (structurally synonymous with Stage Theories frameworks – *Researcher's contention*).

3.5.1 Concerns about Self

Describing the concerns stages, Fuller noted that the *survival concerns* were synonymous with concerns about self and were basically personal in nature. It was when they (student teachers) had their first contact with actual teaching that intense concerns were experienced about their (students') own survival as teachers (*self-survival concerns*) (Fuller, 1969:211). At this phase, doubts arouse as to their abilities and competencies as teachers. These self concerns consisted of covert concerns and overt concerns. Teachers in this stage were covertly concerned about how much support they would have in the school environment, getting along with other school personnel and presenting themselves as professionals. The concerns were classified as *covert* since they were only expressed "during confidential contacts" (Fuller, 1969:220). These concerns were not stated in written form or "routine interviews" (Fuller, 1969:220). The *overt* concerns of teachers were focused on the "adequacy in the classroom" (Fuller, 1969:220), and the concerns were self-directed focusing on their own abilities. Teachers worried about knowing the subject matter, anticipating problems, being allowed to fail, correcting when they do fail and being able to cope with being evaluated. Fuller warned that to some extent, these concerns were overt and that the intensity of concern with self-adequacy (and evaluation) was so great that it was easily underestimated (Fuller, 1969:221).

3.5.2 Concerns about Task

Task concerns dealt with the concerns about teaching, namely, the role of being a teacher, and becoming an adequate teacher and being liked as a teacher. In this phase, concerns about the many demands of teaching such as lesson planning and preparation, too many learners, *etc.* were also categorised. Some of the categories dealt with (see Reed, 1995:58):

- *Concerns about Role:* Statements about the teacher's role in the psychological, social and physical environment of the classroom, school or community.
- *Concerns about adequacy:* Statements about one's own adequacy as a teacher or as a person.
- *Concerns about being liked or not:* Statements about personal, social and emotional relationships with learners.

3.5.3 Concerns about Impact

The concerns of teachers now shifted away from themselves and to the needs of their learners (*impact concerns*). Fuller (1969:222) states that teachers in this stage were concerned about their abilities to:

- Understand learners' capacities
- Specify objectives for them.
- Assess learner gains.
- Partial out their contributions to learner difficulties and gain, and to evaluate themselves in terms of learner gain.

Teachers measured their success by learner achievement and gain, rather than by evaluation by a supervisor. Some of the categories dealing with impact concerns were (Reed, 1995:59):

- *Concerns about teaching:* Statements about the teacher's teaching performances and about whether learners were learning from the materials selected for them.
- *Concerns about learners' needs:* Statements about what learners needed, about whether learners were learning what they needed, and about teaching methods.
- *Concerns about educational improvement:* Statements for improving the lot of learners, about the teacher's own personal and professional development, educational issues and other events outside the classroom that were related to learning.

Impact concerns were linked to the concerns about the learner, namely whether learners were influenced by the teacher's performance, whether the needs of the learners were being addressed and the educational improvement (of the teacher) that would benefit the learners (Fuller, Parsons & Watkins, 1974:6-7). When student teachers began to experience doubts about meeting the educational needs of their learners, they were considered to experience impact concerns.

3.6 FULLER'S THEORY IN A LEARNER-CENTRED AND AN ACTIVITY-BASED EDUCATION ENVIRONMENT

There is no disputing the fact that earlier cognitive theories and theories of adult development were important in providing some theoretical basis or framework for earlier research into the field of teaching and learning or for researchable features within the education sector. During the 1960s and 1970s research on cognitive development had the tendency to become analytical and linear owing to the influence of the Piagetian school of thinking, which had a strong influence on early childhood intellectual practices (see Table 3.1). The linearity influence could be detected in Fuller's Theory of Teacher Development (1969) through her postulation of stage progression from low-level concerns to high-level concerns (Fuller-Brown model). The more holistic and interactive socio-cultural theory of Vygotsky (see Table 3.1) indicates the need for more attention to context and less individualistic understanding of development (Eloff, 2001:63). The influence of Vygotsky's work, as it related to educational discourses, was the notion of social constructivism as opposed to

Piaget's notion of cognitive constructivism (Donald, Lazarus & Lolwana, 2002:74). In South Africa socio-constructivism was the key to the learner-centred and activity-based approach (transformational OBE) adopted in the education and training sector. After more than a decade of education transformation, there has recently been strong support for a *back to basics* approach (traditional OBE), with the emphasis on memorisation and content-based knowledge (the latest curriculum revision resulted in the introduction of CAPS where certain aspects of traditional pedagogy are now being encompassed). [As noted in Chapter 1, these new initiatives for curriculum revision seemed to be obedient to the call for *back to basics* aimed at improving learner performance.] The dichotomy of traditional versus contemporary approaches (see Table 2.1) could be applied to Fuller's theories of teacher development, since development theories (see paragraph 3.2.2) may be viewed as being rooted in attributes that can either be classified as being traditional or as being modern. The notion of teacher-centredness (traditional pedagogy) as opposed to learner-centredness (modern or contemporary pedagogy), was detected within the stages identified by Fuller (1969) and revised by Fuller and Brown (1975). Gilmore, Hurst and Maher (2009) investigated how the Fuller-Brown developmental trajectory was related to the notions of teacher-centredness and learner-centredness. The narrative for interpreting Figure 3.2 commenced with the appearance that neophyte teachers were initially highly concerned with learners. However, this concern decreased after entering the classroom. The focus of the teacher now shifted to concerns on his or her own identity and knowledge (survival: self-concerned), and with time the teachers became concerned about their teaching methods (mastery: task-concerned).

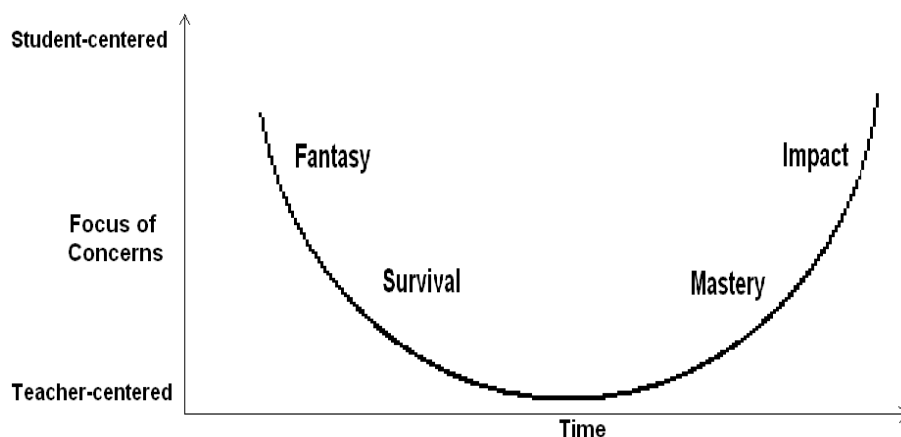


Figure 3.2: Relationship between Student- (Learner-) centredness and Teacher-centredness

(Figure 3.2 sourced from Gilmore, Hurst & Maher, 2009:3)

After an appropriate and satisfactory amount of teaching experience, teachers became less concerned with themselves and were better able to focus on individual learners' needs and their learning outcomes (impact-concerned). Though the authors were unable to depict the qualitative differences between the stages in this figure, it is important to remember that earlier learner-centred concerns, that occurred prior to actual teaching and where student teachers fantasised about the experience ahead, differed from those of the final stage as these concerns (pre-teaching) were largely unrealistic; they were based on the student teacher's experiences as a student alone and expectations for learner learning at this stage were not understood in terms of field practicums (Gilmore, *et al.*, 2009:3).

Even though the notions of teacher-centredness and learner-centredness in the Fuller-Brown model could be interpreted in terms of teaching, it nevertheless relates to satisfying the needs of teachers and the needs of learners respectively. To avoid confusion with the notions of teaching strategies such as the traditional teacher-centred strategy and the contemporary learner-centred strategy, the use of the terms teacher-directed teaching and learner-directed teaching were suggested not to blur the line between teaching environments being either traditional or learner-centred, or an environment where the type of teaching taking place could either be teacher-directed or learner-directed (as was the case in the Fuller-Brown model).

Ormrod (2006:435) states that most instructional (teaching) strategies focus on the learners' learning and the essential difference lies in who has control of the instructional (teaching) activity. If the teacher was in control, then the teaching approach was teacher-centred and if the learners were in control of their learning and the teacher served to guide, facilitate or direct the learning process, then the teaching approach was said to be learner-centred. Most of the research by Fuller and her associates (and even subsequent research) took place within a traditional educational environment. The motivation of this thesis was to consider what the concerns of student teachers were during field practicum when teaching in a learner-centred and an activity-based educational environment (see *Research Question 2*).

3.7 THE CONCERNS OF MATHEMATICS STUDENT TEACHERS

Researchers used the Fuller Theory of Concerns and applied it to detect what concerns student teachers may have as *per* specific-subject field (see paragraph 3.3.2) or if any hierarchical stages of development (as *per* subject-related field) could be detected. The categories of concerns proposed by Fuller (1969) and expanded on by her associates and later on by other researchers provided the framework for many studies and investigations. As noted, other concerns are being identified that fall outside the traditional concerns categories (see Lotter (2004): Appendix H). For this study, Fuller's categories of concerns were used primarily to detect convergence in findings (if any) with an earlier study undertaken by Reed (1995), within a traditional/behaviourist educational environment. Reed had used Fuller's Theory of Concerns to ascertain whether the stages developed into a hierarchy of concerns as proposed by the Fuller-Brown model (1975).

Most developmental theories focus on changes in biological, personality, psychological, behavioural, mental processes and/or other factors such as social and cultural. In education, the developmental perspectives are shifted to the pedagogy and the didactical processes, namely the propositions of teaching and learning models. To comprehend the concerns that student teachers may have when teaching Mathematics, an understanding of how the nature of the subject itself can become a possible source for such concerns. Needless to say, the development of concerns of student teachers and the nature of Mathematics needs to be integrated within such a discourse. The intrinsic nature of Mathematics has proliferated a number of concerns that have manifested themselves amongst learners and students. For instance, when student teachers are about to teach Mathematics, they have a myriad of concerns about what they should do, how they should teach, whether their teaching efforts will be acceptable and whether the outcomes set for the lesson will be attained. To a certain degree, their view of what Mathematics is, the nature of Mathematics and the beliefs their learners may have about the subject, are but a few concerns they may hold as classroom teachers as they are about to undergo the teaching experience.

The contributions from the ancient civilisations have provided a foundational base in understanding the nature of Mathematics which today is rapidly expanding and is mostly discernable through the observable trends in mathematics education, notably through the use

of computers, information technology, interactive web sites, *etc.*, and the application of Mathematics to other spheres of life. The modern views of Mathematics and the development of mathematical knowledge from ancient times have forced us to revisit the parameters that define the nature of Mathematics. The study of the nature of Mathematics does not *directly* answer the question of what the true nature of Mathematics entails. Rather, it provides a sense of perspective through suggestive and illuminating contributions of what was once considered a static discipline to a more modern interpretation of an intellectual discipline being more flexible in its applicability. The modern approaches of cognitive theories and the influence of affective constructs have culminated in the reconceptualisation of what mathematics education entails. For teachers, students and learners, concerns about the nature of Mathematics are more likely to arise in their attempts to understand Mathematics albeit within their own system of beliefs and conceptions. It is within these parameters that an entirely different set of “mathematical” concerns and categories can be developed that fall outside the traditional categories of concerns of Fuller.

Ponte and Chapman (2008:223) in their study on whether mathematical knowledge alone would suffice in addressing issues surrounding concerns about the teaching and learning of Mathematics, noted that on the development of student teachers’ knowledge of Mathematics and knowledge of mathematics teaching there was an inherent connection between these two components. Ponte and Chapman (2008:226) state that “while having a strong knowledge of Mathematics does not guarantee that one will be an effective Mathematics teacher, and that teachers who do not have such knowledge are likely to be limited in their ability to help learners develop relational and conceptual understanding”. Mau (1997:53) examined the concerns of student teachers during their initial school-based training and noted that student teachers who reflected and resolved their concerns gained more professional confidence from their practicum. Christou, Eliophotou and Philippou (2004:157) studied the concerns of teachers in relation to the implementation of a new mathematics curriculum and reported that the concerns were more task focused. The researcher in discussion with the Mathematics student teachers, as part of the feedback after each field practicum session, noted that most concerns were about the same events – coping with mathematics lesson planning and preparation, the uncertainty of a suitable mathematics teaching methodology, high personal expectations of performance and being observed and evaluated by the teacher or lecturer (Hassan, 2009).

[Note: It is not the intent of this study to measure quantitatively the extent or depth of the concerns that student teachers may have about their own teaching. Rather their perceptions of concerns are noted (see *Research Question 2*).]

In sum, this study was confined to using the traditional categories of concerns within a learner-centred and an activity-based environment. However, future research as well as further in-depth studies into the development of mathematics-specific concerns categories is a desirable trend for the field of mathematics education.

3.8 CONCLUSION

Fuller's Theory of Concerns and the subsequent development of this theory by her associates have provided the theoretical basis or framework for other researchers to investigate and study this phenomenon called *concerns* that may manifest itself as strongly as some of the affective constructs discussed in Chapter 2. The work done by Fuller may find relevance in our current education dispensation. In order to maximise the benefits of the field practicum for student teachers, the concerns of student teachers relating to their teaching experiences need to be addressed. The need to bridge the worlds of theory (at post-school institutions) and practice (at schools) in the design and implementation of pre-service teacher-training programmes has become imperative. Student teachers consider the practicum to be a highly valued component of their training as prospective teachers and thus research in identifying student teachers' concerns has to become a necessity. The concerns that prospective teachers, student teachers or beginner teachers or experienced teachers may have, ultimately affect their teaching abilities if their concerns are not identified and addressed. The measurement of student teachers' concerns during field practicum sessions is not sufficient to identify and categorise their concerns. It is important to provide processes that will prevent and manage the concerns and have these processes integrated into teacher-training programmes (see *Research Question 4*). Of importance to this study is the application of the concerns theory to a learner-centred and activity-based education environment and more specifically to a subject-specific sample set.

In retrospect, even though Fuller's study (1969) was conducted within a traditionalist/behaviourist education environment, knowledge of learners' (and students') concerns in a learner-centred/task-based/contextualised education environment from a South African premise could help strengthen our National Curriculum and in particular serve as indicators in improving the mathematical competencies of student teachers as future Mathematics teachers.

An attempt to remedy or alleviate existing and/or emerging concerns of student teachers is the use of and interaction with learning packages (during the intervention strategy and as part of the empirical investigation.). This is done through the teaching of topical issues and newsworthy events during field practicum sessions. An explication of Chapter 4 provides the discourse for the advocacy and the mathematisation of these social context learning packages in the intervention strategy.

CHAPTER 4

SOCIAL CONTEXT LEARNING PACKAGES

4.1 INTRODUCTION

Mathematical tasks sometimes require learners and student teachers to apply whatever mathematical knowledge and skills they have learnt in school and at HEIs respectively to authentic (real-life) problems situated in different contexts. Social context is one such domain and is defined in terms of an overarching description that encompasses a person's position within a social system. Social context provides a universal domain for the sub-setting of a variety of other related contexts (see Figure 2.2). A social context framework was fundamental to the introduction of the subject Mathematical Literacy in the National Curriculum of South Africa since learners are expected to solve non-routine problems in a variety of situations defined in terms of social functions. The relevancy of Mathematical Literacy is the promotion of a sense of socialisation, contextualisation and mathematisation in its design format (DBE, 2011b:8). It is this sense of mathematical social context that was used to develop the content and context of learning packages. As noted in Chapter 2 (see paragraph 2.4), meanings are the constructs that cannot be divorced from the social context, so too is the centrality of social context to cognition and affect.

The LSMs for Mathematical Literacy are embedded in real-world contexts and sometimes requires less-structured mathematical competencies to solve these real-world problems. Mathematical knowledge is put to a functional use in numerous ways in response to the outcomes of a subject that are aimed at meeting the needs of individuals in a quantitative and spatial world. The broad-based real-world phenomena reflected in the LSMs are however not topical in real-time chronology.

The use of content and context that embody real-time, topical issues and newsworthy events provided the framework for the development of learning packages that were used in this study. To divorce learning packages from the LSMs of Mathematical Literacy is to consider that learning packages involved much more than using Mathematics *in context* (an adage fundamental to most definitions of Mathematical Literacy). The socio-mathematical orientation of the learning packages in real-time chronology is elaborated on in this chapter. As part of this study, Mathematics student teachers used the lesson design format the researcher has developed and set out in Appendix G. Landscaping the lesson design entailed starting off with the traditional pedagogy of set establishment (*Introduction Phase*). This type of pedagogy was carried into the *Presentation Phase* with the teaching of conceptual and algorithmic knowledge. A switch was made to a learner-centred and activity-based mode of teaching when dealing with the learning packages in the Presentation Phase. Learners were allowed to discuss and complete these learning packages outside the formal classroom settings.

The use of learning packages was two-fold. Firstly to address the issue of variable LSMs as noted by the 2000 and 2009 Review Committees. Secondly, learning packages were used because of their real-time ontic nature in the intervention strategy [as part of the empirical investigation of the study to ascertain whether it could address in alleviating issues about student teacher' concerns (see *Research Question 3*)]. The rationale for orientating the content and context of the learning packages was grounded on a few general aims of the South African national curriculum (DBE, 2011b:4) namely, “an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation, and promoting the idea of grounding knowledge in local contexts while being sensitive to global imperatives”. To make decisions based on critical and creative thinking, Mathematics student teachers were encouraged to make thoughtful decisions about societal issues as contained in the content of the learning packages.

This chapter reports on the embedding of the learning packages within the social context domain, the mathematisation of topical issues and newsworthy events and the various taxonomies that can be used in the assessment of learning packages in the classrooms.

Furthermore, the use of learning packages in the intervention strategy is reported on from a perspective of modelling, the rationale for intervention and as learning repositories within a web-based environment.

A schema for this chapter is provided in Figure 4.1.

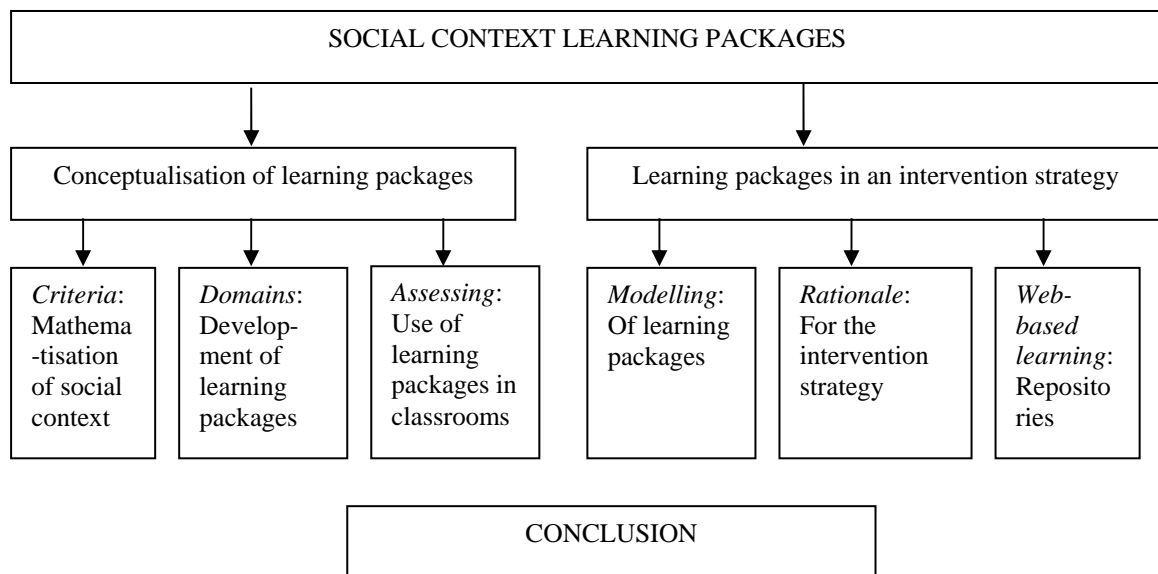


Figure 4.1: Schema for Chapter 4

4.2 THE CONCEPTUALISATION OF LEARNING PACKAGES

Unlike activity sheets or worksheets in mathematics textbooks or alternative LSM resources, learning packages in this study were designed (by the researcher) as self-instructional and self-paced learning systems that allowed learners to achieve outcomes by monitoring and reflecting on the unfolding of events in real-time over a designated period and at the same time engaging in the Mathematics coherent to these events. The degree of Mathematics in these learning packages ranged from being purely Mathematics to having no mathematical structure at the onset until the time that the mathematisation of topical issues had taken place. To illustrate the process of mathematisation (see paragraph 4.2.1.1) the following newsworthy event that made international news in March 2011 was considered.

LEARNING PACKAGE 1: The Japanese Disaster 2011

Week 1: Use at the beginning of the week of field practicum

The earthquake and tsunami in Japan on 11 March 2011 has made us aware of how devastating a disaster can be. The event and aftermath is tragic and the continuing nuclear emergency is a reminder of how fragile society can be. Learners need to make sense of these events and have an opportunity to gain a deeper understanding of what is happening in the world.



(Picture sourced from Wood, 2012: para 1)

Answer the following questions.

1. If the depth of the earthquake was 24,4 km, name a town or city that is more or less the same distance away from your hometown. Find the geographical coordinates (latitude; longitude) of that town or city using an atlas or a map.
2. How far away (in minutes) was the earthquake centre (which was along the 142° line of longitude) from the coast of China at the 130° line of longitude? [Hint: 1 hour = 15° between lines of longitudes (also called meridians).]

3. Japan's earthquake, tsunami and nuclear meltdown emergency have begun not only to affect the world's third-largest economy but starting to cause financial problems for the country. Widespread production halts, rising debt, disruptions to investment flows and soaring energy prices are delivering shocks to Japan's economy. Japanese stocks closed down more than 7.5 percent, wiping out 287 billion United States dollars in the biggest one-day fall. What was the value of the Japanese stocks the day before the earthquake?
4. Explain in your own words how a tsunami is formed when an earthquake occurs deep within the floor of the ocean.
5. Do you think that Japan as an earthquake-prone country should be allowed to build more nuclear power stations after the radiation problems at the nuclear power stations at Fukushima? Debate this issue within your group or with other learners.



[Members of the Japanese military have already begun a clean-up operation in areas affected by radiation from the Fukushima Daiichi power station.]

The unfolding of this newsworthy event in real-time in 2011 prompted a follow-up on this event as more information became known about the catastrophe in Japan and was captured by the following learning package:

LEARNING PACKAGE 1: The Japanese Disaster 2011

Week 1: Use near end of the week of field practicum

The magnitude – 9,0 earthquake and resulting tsunami that struck Japan on 11 March 2011 had left thousands dead and many more homeless. But the farthest-reaching consequence of the devastating natural disaster is the ongoing nuclear emergency at the Fukushima Daiichi nuclear power station. Radiation monitors at the Daiichi plant briefly picked up radiation in the range of 400 millisieverts per hour, 400 times the legal limit and the highest rate since the crisis began. The last giant tsunami recorded in Sendai struck in 869 A.D. Koji Minoura, an Earth scientist at Tohoku University in Sendai, and his colleagues proposed in 2001 that giant waves (tsunamis) visit the region about every 800–1100 years.



(Picture sourced from Wood, 2012: para 1)

Answer the following questions.

1. Name the four tectonic plates which lie under Japan. Which of these two plates are responsible for the earthquake if the collision zone of the two plates was along the east coast of Japan?
2. What is the legal limit of radiation? What would the radiation flow have been one minute after the leakage began?
3. Using Koji Minoura predications, should a tsunami have occurred in the Sendai region of Japan on 11 March 2011? Show your calculations.
4. What do you think the first responsibilities of the Japanese government should be after an earthquake?
5. Draw any logo or design any slogan to show your support to the people of Japan.

4.2.1 The Social Context of Mathematics and Knowledge Construction

An assessment of the content and context of the questions in the above learning packages revealed two focuses: one that dealt with mathematical content issues and the other that dealt with social context issues (hence, the coinage of the phrase *social context learning packages*). To ensure that these learning packages conformed to mathematical contextualisation, the criteria for the development of the learning packages were embedded in a social context framework. An interrogation of the Mathematics and social issues formed the basis for assessing learners' understanding of social context knowledge. The pedagogical assumption was that learners first ought to learn mathematical concepts and operations before applying them to real-life context. Carraher, Carraher and Schliemann (2004:191) state that "daily human sense" guides learners to find the correct solution intuitively without translating contextual problems into algebraic expressions, and that "performance on mathematical problems embedded in real-life contexts is superior to that of context-free computational problems" (p. 187).

Even though context-free or abstract Mathematics is valued for its power, contextualised mathematics is valued for its meaningfulness and relevance (Goldin, 2008:189-190). In recent years, there has been increasing interest in exploring social contextual factors both within and outside of the classroom. Learning in such social context environments can stimulate and enable learners to engage responsibly in quantitative and qualitative arguments relating to social issues at local, national and global levels. Such social context environments provide the basis for the paradigmatic shift from traditional cognitive constructivism to a more contemporary approach to knowledge development such as socio-constructivism.

The revolutionary attitude pioneered by the Swiss founder of cognitive psychology, Jean Piaget, in the 1930s postulated that we are able to cope in the world of our experiences as a result of our cognitive efforts (cognitive constructivism). This epistemological orientation has served as a basis for the introduction of a paradigmatic shift from the traditional *theory of knowledge* (cognition) toward the *construction of knowledge* in the earlier years on research on social constructivism. The constructivist views knowledge as being actively constructed by the learner and not passively received from the environment. A constructivist view of knowledge is that it *fits* experience. If that experience changes, knowledge may need to be modified. This study rejects innateness – that which is present in the mind previous to any experience. The researcher views experience as being acquired through the interaction with different sets of contexts that can serve as a contributory factor in the construction of knowledge, hence the constructivist undertones inherent in the use of learning packages in the classroom. It is important to point out that constructivism makes no ontological claims nor does it dismiss the possibility that there is some pre-existing body of mathematical knowledge rooted in different contextual settings (see Ontological Assumptions, paragraph 1.6). To relate this to the learning of Mathematics, it seems to say that *if* there is some independent, pre-existing body of mathematical knowledge, we cannot know it except through our own experience, and we can *only* know what we ourselves have constructed and modified according to further experience. This concept of *knowing* can invariably be linked to *truth* propositions. According to Davis and Mason (1989:158), “epistemologists are often as concerned with the status of knowledge and in particular *what is truth*, as with the experience of knowing”. It is not the intent of this study to comment on truth propositions in dealing with social context issues, it will rather acknowledge that imbedded in these texts are the distinct possibilities of inclinations towards the biased/non-biased.

Ernest (1991:42) specifies the grounds for describing mathematical knowledge as a social system in his perspective on the development of social constructivism, namely that:

- the basis of mathematical knowledge is linguistic, conventions and rules, and language is a social construction;
- interpersonal social processes are required to turn an individual's subjective mathematical knowledge into accepted objective mathematical knowledge; and
- objectivity itself will be understood to be social.

According to Steffe (1991:192), “a central focus of social constructivism is the genesis of mathematical knowledge and a key distinction is that between subjective and objective knowledge”. The mathematical knowledge of the individual constitutes the subjective whereas publicly shared knowledge constitutes the objective. Anderman and Anderman (2000:67) state that “the fundamental dilemmas facing researchers are the creation of designs that capture how individuals (teachers/students/learners) perceive shared contexts in different ways and how interpreting contexts becomes malleable over time”. For instance, they seek to qualify the ways in which learners and teachers may experience processes such as the mathematisation of social context.

4.2.1.1 The mathematisation of social context

The “Programme for International Student Assessment” (PISA) of the Organisation for Economic Co-operation and Development (OECD) identified five aspects that characterised the process of mathematisation (OECD, 2009:86), and was adapted and modified as an algorithm (by the researcher) in relation to the development of the social context learning packages (see Appendix I for further background information on the OECD and PISA). The process of mathematising Learning Package 1 (Use at beginning of the week/ Use at the end of the week) [see paragraph 4.2], is elaborated on below.

Step 1: Establish a problem(s) situated in reality

The mathematising of topical issues and newsworthy events was done and ran concurrently with the situatedness or context of social issues highlighted in the article or texts that was selected from real-time situations such as the Japanese catastrophe in 2011 (see paragraph 4.2). The reality of the unfolding events was covered by all major news networks (electronic and print media). The problems surrounding the catastrophe became more worrisome as the days went by and a growing concern was what impact it would have on those affected by the tragedy, the cost to human lives and the impending and threatening nuclear fallout. To ensure that these learning packages conformed to contextualisation, the design and development of learning packages were embedded in a social context framework.

Step 2: Identify the relevant Mathematics

The situatedness of the problem in reality could be used to identify certain mathematical concepts by removing redundant information and focusing on the mathematical aspects of the information. The Mathematics identified might seem initially relatively simple but the aim of designing the learning packages was first to consider a generic focus on foundational mathematical concepts that could later be extended into more complex mathematical structures. For instance, the first learning package dealt with the mathematical processes of estimation, longitudinal distance and percentages while the Mathematics of the second learning package dealt with ratio and proportion and the mathematical operation of addition.

Step 3: Solving the real-world mathematical problem

Learners needed to solve the problems in mathematical terms by reflecting on and interpreting the solution(s) in terms of the real-life situation. Learners were encouraged to become constructively engaged in the Mathematics and since there was no prescribed strategy to solve the problem, learners were guided or directed to construct their own solutions or come up with alternatives ways of problem-solving. The mathematical solution(s) was then analysed and interpreted in terms of the context of the real-life problem captured by the learning package.

Step 4: To elaborate on social context issues

To motivate learners to make decisions (biased/non-biased) on topical issues and newsworthy events, a thorough examination of thoughtful decision-making on societal issues was made (within the mathematical domain). An interrogation of the Mathematics and social issues formed the basis for assessing learners' understanding of social context knowledge as well as aiding the construction of mathematical knowledge. Learners were allowed to debate, present arguments, illustrate alternative perspectives, *etc.* on their own (or in groups) understanding of social issues. An aspect of critical hermeneutics is the issue surrounding the biased/non-biased interpretation of text. Exposure to extreme criticism, be it political or otherwise, was avoided when the questions for the learning packages were developed. Learners' responses were also monitored to avoid possible conflict with those who had strong dissenting views or opinions. It was thus important to conform and restrict social issues to the mathematical domain in order to prevent dissention amongst the participants. Nonetheless, the interrogation of social context issues would inevitably expose the readers to dealing with situations affecting their biased/non-biased interpretations. Care was taken not to perpetuate inequity, and cultural, racial, sexist, *etc.* discrimination in the selection of socio-topical issues for use in learning packages.

4.2.1.2 The modelling of learning packages

The mathematical modelling competencies of the student teachers were not assessed in this study even though they had to be involved in the design and compilation of their own learning packages during session 2 of the field practicum. The cohorts of fourth year Mathematics student teachers (part of the Group 1 sample in 2011) were enrolled for the mathematics didactics module MATD 411 and were exposed to the Mathematical Literacy Learning Area domain where they engaged in a mathematical modelling assignment similar to the process in designing and developing learning packages. The difficulties of allowing students to engage in the mathematical modelling of real-world issues and events were noted by Blomhøj and Jensen (2003:128), and they state that the formulation of problems, structuring complex situations and advancing critique of a mathematical modelling process highlights the difficulties that students have in learning "the game of mathematical

modelling”. Since full-scale mathematical modelling is not a core focus of the national mathematics curriculum in South Africa, it nevertheless would have been a time-consuming process for learners at schools, as well as for Mathematics student teachers at HEIs. Cognisance was taken of the fact that insufficient factual knowledge and insignificant experience with real-world phenomena often constituted obstacles for students’ active engagement in the design of their own mathematical modelling activities.

Knowing that mathematisation is often experienced as cognitively demanding, priority was instead given to student teachers, in this study, to use prepared learning packages during session 1 of the field practicum, as they and their learners engaged in the process of unpacking the mathematical content and the social context through thinking, reasoning and reflection, argumentation, problem-solving and representation. The modelling of these learning packages was akin to the modelling processes described by Blomhøj and Jensen (2003:125) who identify six sub-processes in mathematical modelling, which are:

- The formulation of a task that guides you to identify the characteristics of the perceived reality that is to be modelled.
- Selection of the relevant objects, relations, *etc.* from the resulting domain of inquiry, and the idealisation of these in order to make possible a mathematical representation.
- Translation of these objects and relations from their initial mode of appearance to Mathematics.
- Use of mathematical methods to achieve mathematical results and conclusions.
- Interpretations of mathematical results and conclusions regarding the initiating domain of inquiry.
- Evaluation of the validity of the model by comparison with observed or predicted data or with theoretically-based knowledge.

The modelling process described by Blomhøj and Jensen could be interpreted analogously with Figure 4.2. It was in these frameworks that the design features of learning packages were fabricated and placed in a social context orientation.

4.2.1.3 The domains for the development of learning packages

The importance in mathematical knowledge construction is the *mathematics domain*. The mathematics domain is concerned with the “ability of learners to analyse, reason and communicate ideas effectively as they pose, formulate, solve and interpret mathematical problems in a variety of situations” (OECD, 2009:84). The mathematics domain for the development of the learning packages was focused on real-world problems that were topical and newsworthy and beyond the kind of situations and problems typically encountered in tasks, worksheets or activities in a mathematics classroom. In real-world settings, learners are routinely faced with situations in which the use of quantitative or spatial reasoning or other cognitive mathematical competencies can help clarify, formulate or solve a problem. Learners may possess the mathematical skills learned and practised through the kinds of problems that typically appear in textbooks and classrooms. However, the demands of the mathematical treatment of issues in the learning packages might have resulted in these abilities or skills being used in a less-structured context, where the directions were not so clear and where the learners made decisions on what knowledge was relevant and how it might be usefully applied. The PISA mathematics framework (OECD, 2009:90) distinguishes three distinct components within the mathematics domain and they are used as discussion points in relation to the learning packages.

The situation or context in which the problems are located

Problems and their accompanying solutions may occur in a variety of situations or contexts within the life-world and life experience of the learner. The *life-world* refers to the natural, social and cultural environment in which the learner lives. According to Freudenthal (1983: ix), “our mathematical concepts, structures and ideas have been invented as tools to organise the phenomena of the physical, social and mental world”. The *life-experience* refers to the experiences (personal and/or other) acquired from interaction in the family, school, community settings and society as a whole. The context of an event is its specific setting in a situation and includes all the necessary information required to assist in the formulation of the problem(s). According to CAPS: Mathematical Literacy (DBE, 2011b:7), “in exploring and solving real-world problems it is essential that the contexts that learners are exposed to are authentic and relevant and relate to daily life, the workplace and wider social, political

and global environments”. Whenever possible, learners must be able to work with actual real-life problems and resources, rather than with problems developed around constructed semi-real and/or fictitious scenarios (as is sometimes the case in the LSMs). Alongside using mathematical knowledge and skills to explore and solve problems related to authentic real-life contexts, learners should be able to draw on non-mathematical skills and considerations in making sense of those contexts. In addressing unfamiliar contexts, “it is unrealistic to expect that learners will always be exposed to contexts that are specifically relevant to their lives, and that they too will be exposed to all of the contexts that they will one day encounter in the world” (DBE, 2011b:8). In the learning packages the context was authentic as it related to topical issues and newsworthy events, and learners were encouraged to interpret any real-life context that they encountered, irrespective whether the context was specifically relevant to their lives or whether the context was familiar or not. An in-depth analysis of the nature, complexity and familiarity of context/situatedness was not within the purview of this study.

The mathematical content

In the learning packages the mathematical content in headline news or other social context settings was not that easily discernible, unlike in the classrooms where the mathematics content under study is easily evident from textbooks or LSMs. According to Nieuwoudt and Golightly (2006:112), “the selected content primarily has to provide a realistic point of departure for learners in their endeavours to realise the intended outcomes of the situation”. Learners must interrogate textual content and only then will it become clear what specific mathematical knowledge is required, and be guided or directed to this knowledge by the focus of questions that should be mathematical in nature. Mathematical content branches encompass the fields of arithmetic, algebra, geometry and trigonometry, as well as related branches of statistics, probability theory, applied mathematics, *etc.* Despite the structuredness of the school mathematics curricula along traditional content branches, the mathematical content in learning packages was not so coherently and logically organised because of the diverse reporting on the same issue or event, exacting some form of Orwellian control of what was reported and what was too covert to be made public. The range of mathematical content may vary in degree when dealing with mathematical concepts, mathematical structures and mathematical ideas.

In the learning packages, mathematical content was not taught in the absence of context and its focus was on mathematical concepts, skills and foundational algorithmic procedures.

The mathematical competencies

It is essential for learners to possess or to develop the competencies needed to connect topical issues and newsworthy events in which the problem(s) is situated to the mathematical domain. According to the OECD (2009:106), PISA refers to eight cognitive mathematical competencies when dealing with real-world mathematical problems. For purposes of this study, a discussion on all eight competencies was not required. The instructional focus of the learning packages and how student teachers must interact with and use these learning packages (during their field training), made the mathematical competencies (OECD, 2009: 106-107) listed in this paragraph of importance to this study:

Thinking, reasoning and reflection: This involved posing questions characteristic of Mathematics, knowing the kinds of answers Mathematics could offer to questions posed, distinguishing between different kinds of statements (definitions, theorems, conjectures, hypotheses, examples, conditioned assertions) and understanding and handling the extent and limits of given mathematical concepts.

Argumentation: This involved knowing what mathematical proofs were and how they differed from other kinds of mathematical reasoning, following and assessing chains of mathematical arguments of different types, possessing a feel for heuristics and creating and expressing mathematical arguments.

Problem-solving: This involved solving different kinds of mathematical problems in a variety of ways.

Representation: This involved decoding and encoding, translating, interpreting and distinguishing between different forms of mathematical representations, the interrelationships between the various representations and choosing and switching between different forms of representation, according to situation and purpose.

According to Julie (2004:35), “there is a constant search to improve the mathematical offerings to school-goers in South Africa”. The aim of the search is to establish a mathematics curriculum that would result in productive learning.

The incorporation of the learning packages into a mathematics curriculum may offer an avenue that can be further explored within the field of mathematics education since it offers the possibility of broadening the perspective on how Mathematics is viewed (especially the conceptions and beliefs surrounding the nature of Mathematics). The domains supporting the development of learning packages are not restricted only to formalistic Mathematics (within the intra-mathematical domain) but has other domains that provide a rich source of knowledge that feeds into the mathematical domain (see Figure 4.2). For instance, the domains of the real-world and their incorporation within the field of mathematics education have led to redefining the classical nature of Mathematics to a more appropriate and contemporary view of what Mathematics entails. Since the basis of the learning packages encapsulated a social context orientation, the translation of reality into the mathematics domain was modelled according to the following flow-diagram:

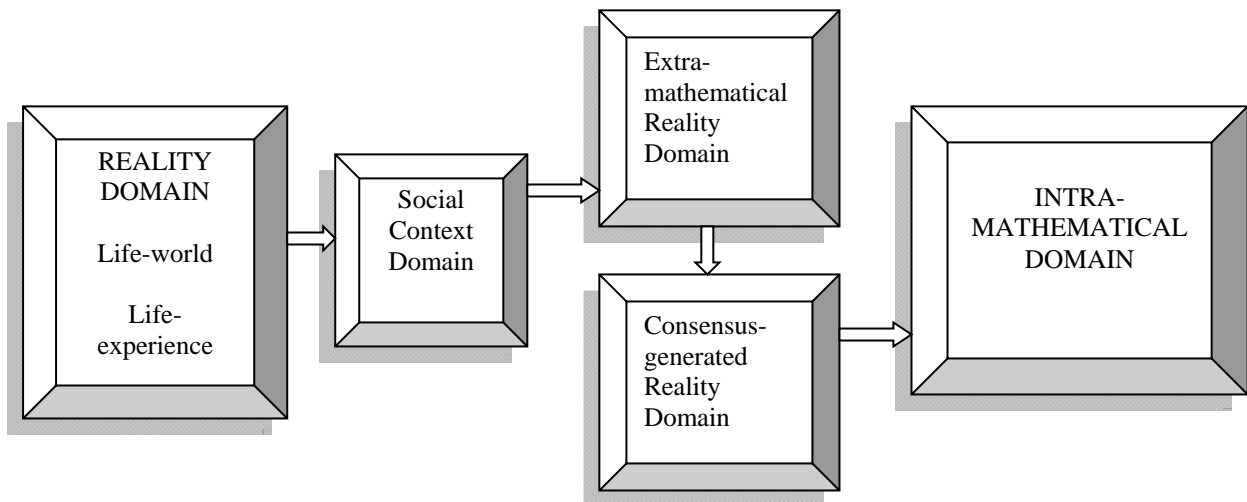


Figure 4.2: The Translation of Reality to the Mathematics in Learning Packages

(Figure 4.2 adapted from Julie, 2004:35)

According to Julie (2004:35), “it is during the process of translation that issues of interests, ideological preferences and power are at stake and contestations manifest themselves”. These contestations occur prior to the subjugation of the issue for which mathematical representation is to be constructed for mathematical treatment. They occur between the domain of the real and that of Mathematics (intra-mathematical). Specific to the discussion on learning packages, the domain of reality for the learners is their life-world and their life experiences which are unique realities to every learner.

It is in this domain that exposure to topical issues and newsworthy events become meaningful to them since this is their reality or real-world as opposed to the structured environment of the school and the classroom. Carraher, Carraher, and Schliemann, (2004:187) state that “performances on mathematical problems embedded in real-life contexts (reality domain) are superior to those of context-free computational problems”. The translation of reality into the social context domain was considered for the purpose of this study. Reality, however, could be translated into many other domains. One such domain is the political dimension. Julie (2004:35) avers that the political orientation finds expression in at least three areas of mathematical activity which all lie in the arena of the applications and modelling of Mathematics.

The reality or real-world of learners is positioned within a social system and thus falls within an overarching description regarded as the social context domain (see Figure 2.2). The significance of social context in the sphere of education is that learning takes place within the life-world and the life-experience of the learners and students (as illustrated in Figure 4.2). Teachers’ awareness of the social context is critical. If teachers are willing to accept the responsibility as facilitators of social context, they must also be aware of the possibility that their perception of the social context may not be consistent with that of others in the classroom such as those of their learners. Teachers may experience classroom activities, relationships and culture differently from their learners. This is merely one example of the possible challenges and concerns a teacher (as well as student teachers) may face when considering his or her role in the pedagogy of social contextual teaching and learning. [Refer to other concerns experienced by student teachers and teachers in context of classroom teaching: see Appendix C.] Nieuwoudt and Golightly (2006:114) state that “the teacher has the duty and the responsibility to provide a relevant and realistic environment and create a powerful learning context for all learners in the class”. An important contribution to our sense of social context is the notion that it extends beyond the classroom and into existing cultural communities, acknowledging the role of diversity in educational contexts. Learning to become a facilitator of social context means one must continuously reflect on the outcomes of teaching and revise one’s personal sense of responsibility to learners’ social needs. Teachers who recognise the importance of social context should realise that this type of work is an enduring process contributing to their own professional development (Donald, Lazarus & Lolwana, 2002:168).

The social context domain feeds into the extra-mathematical domain, by presenting issues or events for mathematical contextualisation and mathematisation. Other elements, such as technical, physical, financial, political, environmental and so forth, also reside within this domain. Issues in this domain are complex and exposed to the influences of many factors Julie (2004:35). For instance, to resolve conflicts, interpretational variations, argumentations and debates emanating from the complex issues or events of the extra-mathematical domain, a consensus-generating domain allows for these deliberations to be ameliorated. It is, however, in this consensus-generating domain that ideological intentions and issues of bias and non-bias are revealed. In order to overcome these differences of interests and intentions, consensus is reached in this domain based on purpose. Once this is achieved, the presentation of topical issues and newsworthy events can be translated into the intra-mathematical domain for mathematical treatment.

4.2.2 Criteria for Assessing the use of Learning Packages

As stated earlier in this chapter, the social context learning packages used in this study (albeit on the foundational aspects of Mathematics) has the potential to be developed further for use in higher levels of Mathematics, as well as to mathematised topical issues or newsworthy events into the more formal or complex structures in the mathematics domain. The level descriptors (see Table 4.1) can be more appropriately used at higher standards of mathematical offerings. It is possible to rate the mathematical competencies of learners using the learning packages (as per level of the mathematical complexities inherent within these learning packages) according to the following PISA 2009 assessment framework (OECD, 2009:122) illustrated in Table 4.1.

Table 4.1: PISA-Six Competency Levels for Assessing the use of Learning Packages

Level Descriptors	Description of competencies
SIX	Learners can conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations. They can link different information sources and representations and flexibly translate among them. Learners at this level are capable of advanced mathematical thinking and reasoning. These learners can apply this insight and understandings along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for tackling novel situations. Learners at this level can formulate and precisely communicate their actions and reflections on their findings, interpretations, arguments and the appropriateness of these to the original situations.
FIVE	Learners can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Learners at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterisations and insight pertaining to these situations. They can reflect on their actions and formulate and communicate their interpretations and reasoning.
FOUR	Learners can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic ones, linking them directly to aspects of real-world situations. Learners at this level can utilise well-developed skills and reason flexibly, with some insight, in these contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
THREE	Learners can execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem-solving strategies. Learners at this level can interpret and use representations based on different information sources and reason directly from them. They can develop short communications, reporting their interpretations, results and reasoning.
TWO	Learners can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Learners at this level can employ basic algorithms, formulae, procedures or conventions. They are capable of direct reasoning and making literal interpretations of the results.
ONE	Learners can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations.

Source: PISA 2009 assessment framework (OECD, 2009:122).

However, a more appropriate and relevant assessment taxonomy framework that was more congruent with the content and context of the learning packages proposed in this study is the taxonomy given in the CAPS (Mathematics Literacy) document (DBE, 2011b:102-106).

Table 4.2: Mathematical Literacy: Four Competency Levels for Assessing the use of Learning Packages

Level Descriptors	Description of competencies
ONE	<p>KNOWING:</p> <ul style="list-style-type: none"> ■ Learners are able to familiarise themselves with the context in which the problem is situated. ■ Learners are able to interpret contextual information and use familiar techniques to solve the problem.
TWO	<p>APPLYING ROUTINE PROCEDURES IN FAMILIAR CONTEXTS:</p> <ul style="list-style-type: none"> ■ Learners are able to perform well-known procedures and complete common tasks in familiar contexts. ■ Learners are able to know what procedures are required and the necessary information needed to solve the problem in familiar contexts.
THREE	<p>APPLYING MULTI-STEP PROCEDURES IN A VARIETY OF CONTEXTS:</p> <ul style="list-style-type: none"> ■ Learners are able to solve problems using well-known procedures or methods, but where these procedures or methods are not immediately obvious, then learners use any appropriate technique(s). ■ Learners can make decisions regarding the appropriate content, methods and non-mathematical considerations needed to solve the real-world problem(s). ■ Far less guidance or direction is given at this level in comparison to Level 2.
FOUR	<p>REASONING AND REFLECTING:</p> <ul style="list-style-type: none"> ■ Learners are able to make decisions, give their opinions or make predictions about a particular scenario based on given information. ■ Learners are able to engage in questions that require thinking and reasoning, argumentation, problem-solving and representation (as in the case of learning packages). ■ Learners are able to use non-mathematical techniques that may define or determine the solution to the problem posed.

Source: Adapted and modified from *Description of levels in the Mathematical Literacy assessment taxonomy framework*, (DBE, 2011b:102-106).

Elaborating on the description of four levels of competencies, it is important to note that in order to promote the use of both mathematical and non-mathematical techniques and considerations in exploring and making sense of authentic real-life scenarios, the taxonomy (in Table 4.2) must not be seen as being associated exclusively with different levels of mathematical calculations and/or mathematical complexities (DBE, 2011b:102). Rather, in determining the level of complexity and cognitive demand of the Mathematics in learning packages, consideration must be given to the level of complexity of the topical issues and newsworthy events in which the problem is situated, the influence of non-mathematical considerations on the problem especially social context and the extent to which the learner is required to make sense of the real-world problem on their own without guidance or assistance.

4.3 THE RATIONALE FOR USING LEARNING PACKAGES IN AN INTERVENTION STRATEGY

First and foremost, within the South African education context, learning packages were used in the intervention during field practicums (within learner-centred and activity-based classroom environments). Notwithstanding the appropriateness of allowing learners to interact with these learning packages on their own or through guided assistance, Chisholm (2005:194), citing Muller (2000, 2001), cautions that the problem with educational progressivism's learner-centred romanticism is that it may short-change the learners of the so-called disadvantaged communities. Cognisance must be taken to ensure that the implementation of any attempts to improve learner achievement and performances will not just favour well-resourced schools with well-qualified teachers (as noted by Jansen, 1999: 203). These learning packages should be developed within the curriculum design ambit to address, among others, improving the quality of learning support materials, as well as to allow teachers much more flexibility to become innovative and creative in using learning repositories in their approaches to teaching Mathematics. Most textbooks (or even contemporary learning materials) support the use of Mathematics in varied contexts at some level and may range from the simplest form (informal) to the more complex structures.

The portrayal of real-world issues or events in mathematical tasks, worksheets and activity sheets may lay claim to an ontic orientation but the span of real-time chronology is lacking as these tasks, worksheets and activity sheets may have been in print form as textbooks for a number of years. Kajander and Lovric (2009:180), acknowledging that textbooks remain a fundamental teaching resource, nevertheless suggest that more attention be paid to the presentation of Mathematics, and that furthermore, analyses of textbooks should include developmental as well as subject matter scrutiny to prevent the creation of mathematical misconceptions. To circumvent possible misconceptions around content and context, the introduction of topical issues and newsworthy events (in the content and context of learning packages) are open to scrutiny in the public domain. However, it is noted that barriers to understanding contextualised mathematics are rooted in language and in reading and comprehension skills which could result in learners finding contextualised problems much more difficult than context-free mathematical problems. Learning packages seek to address these issues which have become problematic in contextualised mathematics (see Murray, 2003:40), namely:

- Learners who are not familiar with the context: so-called real-life context is not necessarily accessible to learners.
- The context has unpleasant connotations: this includes unpleasant overtones that may be political, sexual, socio-economic, *etc.*
- Limited context: the concepts and skills developed by learners may not be transferable to other contexts.

The notions of unfamiliar context, unpleasant connotations and limited contexts need to be addressed and it was this niche that the learning packages explored by focusing contextualised mathematics on topical issues and newsworthy events. Goldin (2008: 189-190) states that even though context-free or abstract Mathematics is valued for its power, contextualised mathematics is valued for its meaningfulness and relevance.

Supportive of the rationale for using learning packages in an intervention strategy was the notion of *knowing* that can invariably be linked to *truth* propositions. According to Davis and Mason (1989:158), epistemologists are often as concerned with the status of knowledge, and

in particular *what is truth*, as with the experience of knowing. It is not the intent of this study to comment on truth propositions in dealing with topical issues and newsworthy events. It will rather acknowledge that imbedded in these texts are the distinct possibilities of inclinations towards the biased/non-biased to which student teachers and learners are encouraged to engage in. Furthermore, by encouraging thoughtful decision-making, these learning packages were used in an intervention to measure whether there were any changes in the concerns that student teachers might have during field practicum sessions. These concerns might influence how student teachers teach contextual mathematical problems, which in turn could reveal their (student teachers') beliefs about the nature of Mathematics and how best contextualised mathematics is taught.

4.3.1 The Rationale behind the Intervention

The rationale for introducing the use of learning packages in the intervention strategy was primarily targeted at the amelioration of student teachers' concerns when engaging in contextualised mathematics. As part of their field practicum sessions, student teachers had to teach contextualised mathematics as part of a prescribed lesson format. In addressing problems associated with context (noted earlier by Murray, 2003:40), learning packages were used in the empirical part of the study in an intervention strategy to measure whether any changes in the concerns of the experimental sample had taken place as a result of the utilisation of these packages in a pre-post research design format (as opposed to the control sample who was not subjected to any intervention strategy). As a consequence, this study focused on the pedagogical implications of using learning packages as a mediator of student teacher concerns. Assumptions were that individuals learned best when allowed to pursue their learning in the mode most suitable to them and that they were more interested in activities which differed from traditional textbook and the question-answer (Socratic) approaches. The reason for using topical issues and newsworthy events in these learning packages was to equip the learners to make thoughtful decisions about societal issues and events, as well as to skill them to critically engage with mathematical issues that occurred in contemporary real-life situations. Not much work is done in the field of dealing pedagogically with thoughtful decision-making of social context mathematical issues at school or teacher education level.

However, one project of noted interest was the Teacher Education Programme: South-North Project, a collaboration between Norway (University of Bergen) and South Africa (the University of the Western Cape). One of the project outcomes was the finding of Mikalsen and Julie (2005:3), who state that the virtual non-existence of classroom-based exemplars of learning resources dealing with social context mathematics needed to be addressed. In essence this meant that there was a need for a series of exemplary learning packages to be designed and implemented in school classrooms as part of a teacher education programme (see paragraph 7.2.3). More specifically, these learning packages must be designed to extract strategies and learning trajectories for implementation in classrooms during field practicum sessions. According to Berieter (2002:321), “the solution of problems formulated on the basis of perceived needs (shortcomings) and obstacles is inherently interventionist”. The obstacles and perceived shortcomings in the traditional forms of contextualised mathematics are still beset with issues concerning contexts (noted earlier) and real-time chronology of issues and events respectively.

The focus of the intervention strategy used in this study was to address perceived concerns of student teachers during field practicum sessions, as well as to get student teachers conversant with the notion of social context mathematical issues in contemporary education. In addition, the use of thoughtful decision-making through the use of social context mathematical issues was encouraged through the use of these packages to assist in the development of innovative, effective and strategic teaching methods as opposed to the traditional forms of teaching. As far as the learning functions were concerned, the learning packages used in this study were focused on promoting active and reflective learning, even if they described opposing learning styles. According to Tonkes, Isaac and Scharaschkin (2009:497), “active learning occurs when doing something active, while reflective learning takes place introspectively”. The expectation now is that student teachers must encourage their learners to become actively involved in solving the mathematical problems and at the same time reflect on addressing the social context issues highlighted in the learning packages. It is the researcher’s contention that these packages can be used as tools to support the deep reflective thinking that is essential for meaningful learning to take place.

4.3.2 Web-based Learning Repositories for access to the Learning Packages

The nature of the learning packages (as described in this study) alluded to their content and context when dealing with topical issues and newsworthy events in real-time chronology. To avoid pseudo-reality from setting in when dealing with contextualised mathematics, realistic contexts need to be fairly topical and newsworthy so as to establish a sense of active engagement in the unfolding of issues and events. The introduction of technology resources into mathematics classrooms promises “to create opportunities for enhancing learners’ learning through active engagement with mathematical ideas” (Al-A'ali, 2008:1507). Online environments facilitate access to and retrieval of information. McNaught (2007:8) states that “such online environments can be useful in evaluating the usefulness of any resource” (in this case, the learning packages).

The importance of e-Learning has become a major focus of education institutions and the notion of sharing has allowed teachers to find available resources online. According to Lee (2001:121), unlike learning in traditional classrooms, web-based learning (or e-Learning) presents a new environment which can either be accepted or rejected depending on the adaptation of the learning process. Al-A'ali (2008:1515) states that in order to maximize the benefits of using Information and Communication Technology (ICT), such as web-based learning repositories for teaching Mathematics, the benefits need to be made clear to student teachers and teachers as they need to incorporate these packages in the teaching process in such a way that learners use them in a systematic manner for learning, revising and practising. The relationship of this study with e-Learning will be the proposal of a webpage (see paragraph 7.3.3) to host the upload of social context learning packages, and allowing learners, student teachers, teachers or any institution access to download these packages for use in any education setting or as part of Computer Assisted Instruction (CAI) or as Computer Assisted Learning (CAL) tools. Positioning learning packages within web technology could possibly influence the way learners learn, especially promoting responsive feedback, individual involvement and co-operation through collaborative learning.

4.4 CONCLUSION

In sum, the use of learning packages as part of Mathematics student teachers' lesson presentations during field practicum might further inform this study of how student teachers and learners interact with social context issues. The influence of affect constructs on the learning of Mathematics (with special reference to the development of mathematical competencies of learners/students) and the perceived concerns experienced by student teachers during field practicum, may become indicators as to the needs in addressing problematic issues student teachers experience at institutional level and in the field. It is the researcher's contention that the problems experienced by student teachers (at institutional and at field levels) have pointed to a need for some form of assistance.

The use of learning packages in an intervention strategy is unique in the sense that it replaces static contextualised mathematics in textbooks or printed LSMs by introducing topical issues and newsworthy events within real-time chronology in an unfolding sequence of real-world situations. During field practicum sessions, student teachers were expected to teach contextualised mathematics at a certain stage of the lesson. Instead of using the so-called traditional form of word problems or contextualised mathematics, which has proven to be problematic in so far as language and context are concerned (as highlighted in this chapter), learning packages in an intervention may help contain the proliferation of student teachers' concerns. Left unchecked, it may have an effect on student teachers' abilities to teach contextualised mathematics. Hence, the replacement of traditional contextualisation with an innovative and creative contextualisation in a more realistic setting. Social context learning packages should be seen as a challenge in invigorating an environment of collaboration and *esprit de corps*. The degree of influence that these learning packages have on mitigating student teachers' concerns is one of the measurable focuses of the empirical study in Chapter 5.

CHAPTER 5

RESEARCH DESIGN AND METHODOLOGY

5.1 INTRODUCTION

The review of literature in the preceding chapters involved the analyses of information relating to the research topic as set out in the research questions formulated in Chapter 1. The significance of the literature review process was to provide an understanding and insight on what has already been done in the research arena as per research topic, and could provide the rationale on what needs to be done to justify the significance of further or new research in related topics. For this study, the review of literature demonstrated the underlying assumptions and prepositions behind the research questions that were central to the research topic and also helped to delineate the research questions and embed these questions within a framework or model that served as a guiding force in facilitating the research process. It is within this ambit that this research investigation had positioned itself to explore the impact of the study variables (identified in paragraph 1.2) on the teaching and learning of Mathematics. At this juncture, the measurement of the variables (be they quantitative or qualitative) now becomes a significant part of the empirical study. In addressing the problem statement (see paragraph 1.2), the two shortcomings noted by the 2000 and 2009 Review Committees as being the inadequate orientation, training and development of teachers and the learning support materials that are variable in quality. These two shortcomings provided the rationale for an empirical investigation. To address the problem statement, four research questions were formulated (see paragraph 1.2) that dealt with the influence of affect on learning (institutional), the concerns of student teachers (during field training), the use of learning packages by student teachers (as the intervention strategy) and the recommendations for a mathematics programme (institutional) and a lesson programme (field level).

The exposure of Mathematics student teachers not only to cognition but also to affect can promote a much more encompassing approach to the teaching and learning of Mathematics, where knowledge construction and development are not just the ultimate goal, but also the ability to address affective issues in Mathematics. In so far as the quality of the LSMs is concerned, the efficacy of using the social context learning packages (as additional to the LSMs) in the intervention strategy (to possibly attenuate the concerns student teachers may have during field practicum sessions) is reported on in Chapter 6. This chapter reports on the methods and procedures used in the measurements of the study variables by providing an expositional framework for the empirical investigation in the form of the following schema (Figure 5.1) for Chapter 5:

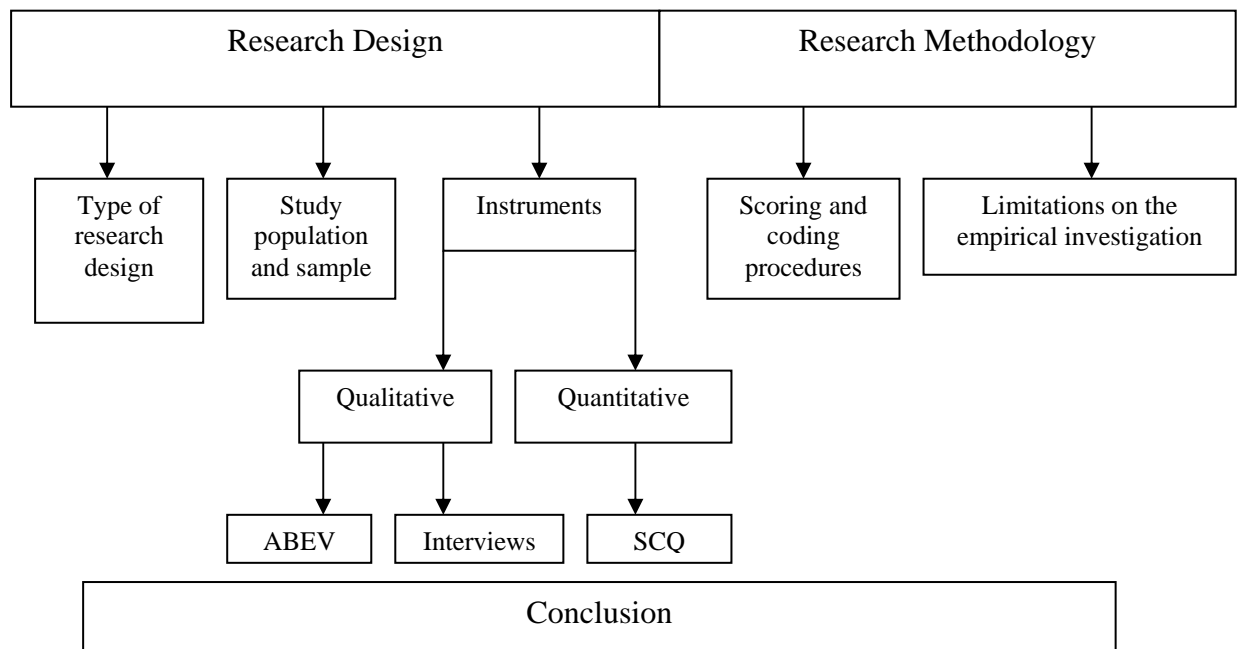


Figure 5.1: Schema for Chapter 5

5.2 RESEARCH DESIGN AND METHODOLOGY

5.2.1 Research Design

The research design addresses the type of study that is undertaken in order to provide acceptable answers to the research questions and provide the rationale for the selection of a specific design.

An applied research design format was adopted in this study that used field survey-type techniques to gather the data (questionnaires/interviews). It is field-oriented because of its naturalistic settings within institutions (institutional learning) and schools (field practicum). According to Best and Kahn (2003:19), “most education research is applied research for it attempts to develop generalisation of the teaching-learning process as well as how educators and learners respond in educational settings”. The selection of this research design was based on the assumptions/perspectives presented in paragraph 1.6. Though the study was qualitative (narrative) in nature, the research design incorporated aspects of quantitative (descriptive and inferential) research. In its entirety, this research design engaged a mixed-mode of inquiry illustrated by the quan + QUAL typology (indicating that the lower case quan denoted the lower priority of the quantitative orientation while the upper case QUAL indicated that the qualitative approach had higher priority). According to McMillan and Schumacher (2001: 428-429) “such a mixed-mode approach enhances the validity and credibility of a study”. The quantitative mode of inquiry was non-experimental in design (descriptive and inferential) whereas the qualitative mode was of an interactive nature (open-ended responses and interviews).

5.2.2 Study Population and Sample

The study population consisted of Mathematics student teachers from both the NIHE site and the Potchefstroom campus of the NWU. Sampling was done purposively and the sample demographics focused on the dichotomous grouping, namely *Group 1* and *Group 2*. At the commencement of empirical investigation (in 2011), the composition of Group 1 ($n=40$) consisted of the first-year level up to third-year level Mathematics student teachers based at the NIHE site and who had enrolled for the Bachelor of Education qualification (Senior/FET Phase). The primary focus of this study was on these cohorts of student teachers that shared dual registration with the NIHE and the NWU. (Programme delivery is still contracted to the NIHE by the NWU.) Group 1 became the experimental sample for the quantitative part of the empirical investigation and was exposed and subjected to the intervention strategy. The population for Group 2 ($N=100$) consisted of the first-year level up to third-year level Mathematics student teachers based at the NWU (Potchefstroom campus) with participatory samples of $n_1=49$ and $n_2=24$ during the first semester and second semester of 2011 respectively. This group became the control sample and was not part of any intervention.

The subject population for the empirical study was therefore confined to the continuous first year-level up to the third-year level Mathematics student teachers who would have progressed to one higher level of study respectively in 2012. Even though the sample sizes differ considerably, the ideal would have been to have a bigger experimental sample. The reality, however, was that a substantial part of the study was undertaken primarily at the NIHE, in the Northern Cape Province. Although the largest province in South Africa, it is still very rural and sparsely populated. There is still a distinct disparity in student population numbers at the NIHE with well-established universities in other provinces.

The geographical demarcation for the study incorporated the following areas:

- The Galeshewe campus of the NIHE (Kimberley, Northern Cape Province) where the institutional (classroom) investigation was conducted. This is the current site of the Faculty of Education (previously known as the Education Cluster) of the NIHE.
- Placement schools within the educational districts of the Northern Cape and the North-West Provinces, selected by student teachers to do their field practicum during the first and second semesters of the 2011 academic year.

In addition, the study population also incorporated a group of fourth-year Mathematics student teachers that shared dual registration with the NIHE and the University of the Western Cape (UWC). This group was used as the pilot sample ($n=30$) and individuals were randomly selected for participation in piloting both the fixed-item and open-ended questionnaires. The pilot sample was used for the purpose of establishing content validity for the questionnaires.

5.2.3 Instruments

5.2.3.1 *Qualitative research instruments*

This research was predominantly qualitative in nature and used the following measuring instruments to aid its qualitative reporting:

1. A *40-item open-ended questionnaire* focusing on attitudes, beliefs, emotions and values (the *ABEV Questionnaire* – an acronymic title) within the context of mathematics learning (see Appendix A). The affect items were accordingly structured on the questionnaire for purposes of categorisation and analysis. The coding used for the *ABEV Questionnaire* was inductive since the codes were developed while examining the data. The qualitative measurement of affect was conducted at institutional level and administered to Mathematics student teachers only from the NIHE site. Measurements were once-off and a longitudinal study on affect was not within the scope of this study.

Features of the affect-oriented questionnaire:

- The questionnaire is known as the *ABEV Questionnaire* (acronym for **A**ttitudes, **B**eliefs, **E**motions and **V**alues).
- For the *attitude towards mathematics* items on the questionnaire, the researcher had adapted the *Attitude towards Mathematics Questionnaire* (see Appendix C, Hassan, 2004:221) for purposes of particularisation to this study.
- For the beliefs items, the empirical work undertaken by researchers Halverscheid and Rolka (2006), Eichler (2006) and Philipp (2007), among others, was used to aid the formulation of these items.
- The emotion items were formulated in terms of the empirical literature of Evans and Zan (2006), Kaasila, Hannula, Laine and Pehkonen (2006), *inter alia*, and within the theoretical premises provided by Pintrick and Schunk (2002).
- The identification of value items was informed by the work undertaken by Rhodes and Roux (2004), and the researcher further proposed a set of predictors in assessing perceived learners' values towards mathematics learning.

The rationale for using open-ended questions to qualitatively measure student teacher responses of their affect, in this study, was based on the premise that such questions could communicate the levels of student teachers' internalised feelings towards Mathematics. In addition, students did not need to feel restricted as is in the case of multiple-choice or fixed-item questions. It also allowed this researcher to interpret and use multiple criteria in assessing responses. External validity of the *ABEV* questionnaire was done by piloting it with the cohorts of fourth year UWC Mathematics student teachers. The testing of the questionnaire was conducted to ensure the accuracy of expression, appropriateness of language (in terms of difficulty) and clarity of statements. Based on the comments and statements of this pilot sample, the necessary adjustments to the *ABEV* questionnaire were effected before implementation (see Appendix J for coding categorisation).

2. *Interviewing* Mathematics student teachers on their examination, interpretation and teaching of topical issues and newsworthy events when using learning packages. Transcriptions of their responses were made as to their perceptions of using learning packages in their mathematics lessons during field practicum sessions. Semi-structured interviews were conducted through the use of an interview guide (as opposed to the use of an interview schedule for structured interviews) (see Appendix B). Since learning packages were used in the intervention strategy, interviews were conducted only with the targeted experimental sample at the end of the two field practicum sessions (in 2011).

Features of the interview guide:

- The guide involved a list of topics that had a bearing on examining thoughtful decision-making (bias/non-bias) on topical issues and newsworthy events within a social context framework, as well as in the manner in which student teachers engaged in the Mathematics of the learning packages.
- The advantage of using a semi-structured interview was reflected in the construction of the interview guide since it allowed the interviewee to raise other issues of the topics not addressed by the researcher.

It also allowed the researcher to use probes with the view of clearing up vague or ambiguous responses or to ask for elaboration of incomplete answers. The interview guide was pilot tested with the UWC sample.

- In semi-structured interviews the interviewer may adapt the formulation, including the terminology, to fit the background and education level of the respondents (Welman & Kruger, 2004:161).

Trustworthiness of the qualitative research instruments: The technique of triangulation was used to ensure the *internal validity* of the student teacher responses as captured during interviews and written feedback. Triangulation refers to the use of multiple perspectives to check one's own position against, and in this study it was applied as *per* description. According to Maree and Van Der Westhuizen (2010:39), triangulation is critical in facilitating validity and establishing data trustworthiness, as well as checking the extent to which conclusions based on qualitative sources are supported by a quantitative perspective and *vice versa*. Of importance to the interviewing process was the trustworthiness of the information collected (expressions and perceptions), hence there was a need to ensure descriptive and interpretative validity. Descriptive validity refers to the factual accuracy of an account with no distortion of what is being heard or making up events based on inferences while interpretative validity refers to the meanings attributed to the words of the respondents. The researcher must interpret the respondents' words accurately (Gay, Mills & Airasian, 2009:375). In this study, the core responses of the participants were noted (see paragraph 6.2.2). The mixed-mode design for this study uses the following triangulation technique (Figure 5.2) to establish descriptive and interpretive validity and data trustworthiness:

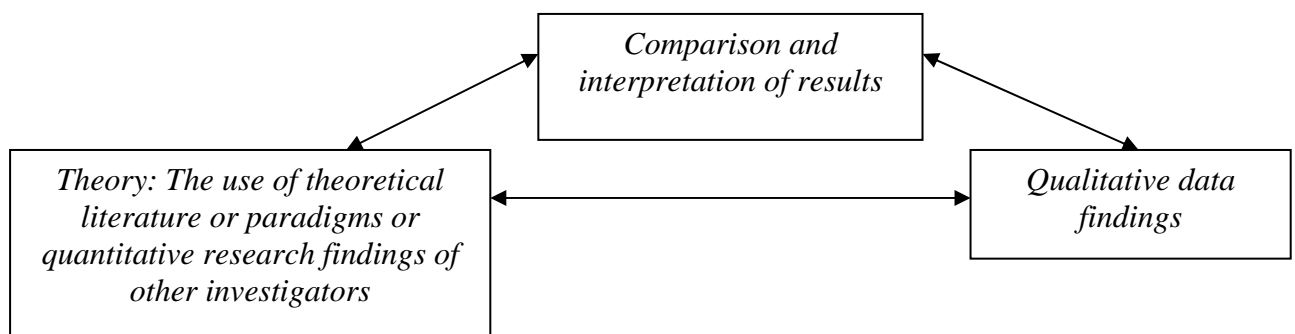


Figure 5.2: Triangulation for a Mixed-mode Design

5.2.3.2 *Quantitative research instrument*

The following instrument was used for quantitative analyses:

1. A 15-item Likert-type *Student Concerns Questionnaire (SCQ)* (see Appendix C) to assess and examine the concerns of Mathematics student teachers during field practicum sessions. This questionnaire was administered to both the experimental sample (Group 1) and the control sample (Group 2) in a pre-test and post-test format during each of the two field practicum sessions of 2011.

Features of the concerns questionnaire:

- Fuller's concerns categories of *concerns about self*, *concerns about task* and *concerns about impact* were used in this study (referred to as sub-scales). The student teacher concerns' items in the sub-scales were modified as was done by Reed (1995).
- The construction of the featured items for the *SQC* was informed by studies of other researchers, *inter alia*, Christou, Eliophotou and Philippou (2004) and Ponte and Chapman (2008).
- The *SQC* was used during field practicum sessions and was coded according to an *a priori* set of codes, that is, codes developed before examining the data.
- Measurements were taken before and after the two field practicum sessions to detect any developments in the concerns of student teachers as expounded on by the Fuller-Brown model for teacher development.

Statistical techniques for quantitative measurement

Descriptive and inferential statistics were used (for analysing the quantitative data) as it dealt with the description and summarising of the data obtained from the groups used in this study. Since only one variable (namely *concerns*) was considered in the quantitative measurement, the analysis was thus univariate in nature. The use and comparison of basic descriptive and inferential data, such as the means, standard deviations and correlations, were necessary to make the results meaningful and to use them to initiate appropriate changes. Without such comparative data the survey would have been of little or no use (according to Welman & Kruger, 2004:209). The mean is considered the most commonly used measure of central tendency. The standard deviation, in turn, measures how the values fluctuate about the mean. The smaller the value for the standard deviation, the more concentrated or homogeneous the data is (Berenson & Levine, 1996:110). The means and standard deviations of items within the categories of concerns (referred to in the empirical part of this study as the sub-scales of *self*, *task* and *impact*) were computed (as paired samples – see Appendix L) so as to ascertain which items Mathematics student teachers (from both groups) were mostly concerned about. The quantitative interpretation of this statistical data was done in accordance with a Likert-type scale used in this investigation. (Note: The middlemost statement “not concerned/concerned” was eliminated from the Likert-type scaling procedure due to the proneness of some respondents to give a neutral answer. See Appendix C.)

Of importance to this study too, was the use of factor analysis to determine how closely various items on the SCQ were related to form sub-scales (factors), with each factor representing several different items on the SCQ (see Appendix C: Information relating to the SCQ). Factor analysis seeks to ascertain whether the number of factors and the loadings of measured items on them conform to what is expected on the basis of a pre-established theory (such as the Fuller-Brown model). According to Schwarz (2011:9), “factors turn out to be more efficient than individual items at representing outcomes and the goal of factor analysis is to represent items that are related to one another by a more general term” (such as either *self*, *task* or *impact*). The extraction of factors in this study was made using the Principal Axis Factoring (PAF) method. “The aim of PAF is to determine the cause of the correlation structure (factors cause the correlation between items on the questionnaire). PAF seeks the least number of factors which can account for the common variance shared by a set of items

(see Schwarz (2011:14 & 29)).” Kaiser, Meyer and Olkin (KMO) developed the “measure of sample adequacy (MSA) test” which became the standard test procedure for the factor analysis. “The KMO tests whether or not the partial correlations among variables (items on the SCQ) are small and uses the MSA criterion to indicate the degree to which the variables are related, thus helping to indicate whether using factor analysis makes sense (Schwarz, 2011:25)”. The following frame of reference for the KMO index was used (see Schwarz, 2011:26):

0,00 to 0,49 = unacceptable
0,50 to 0,59 = miserable
0,60 to 0,69 = mediocre
0,70 to 0,79 = middling
0,80 to 0,89 = meritorious
0,90 to 1,00 = marvellous

[Note: As a rule of thumb, KMO should be 0,60 or higher in order to proceed with factor analysis. Kaiser (1970:401) suggested 0,50 as the cut-off value and 0,80 or higher as a desirable value.]

Bartlett’s Test of Sphericity was applied to test correlation of items and a computed significance value of 0,05 or less would also be a good indication to continue with the use of factor analysis. The test uses the Null Hypothesis H_0 : The random sample comes from a universe in which all variables (items) are completely uncorrelated. The Null Hypothesis may be rejected on the basis of a very high test statistic (Approximate Chi-Square) and an extremely low significance value, and as a consequence accepting the fact that the variables are not completely uncorrelated (Schwarz, 2011:24). For this study, data was collected from the same respondents (Group 1 and Group 2) under repeated conditions so as to reduce or eliminate individual differences as a source of between group differences. The design included measurements repeated over time (Session 1 and Session 2 of the 2011 field practicum).

Since there was a variation between group sample sizes, the possibility of a large error variance existed. Consequently the use of repeated measures over time provided a way of accounting for this variance, and in so doing reducing error variance. The repeated measures Analysis of Variance (rANOVA) was computed for this statistical process. One of the greatest advantages of using rANOVA is the ability to partition out variability due to individual differences.

The schema below (Figure 5.3) indicates the manner in which the quantitative measurements for the study variable *concerns* were done within a temporal range.

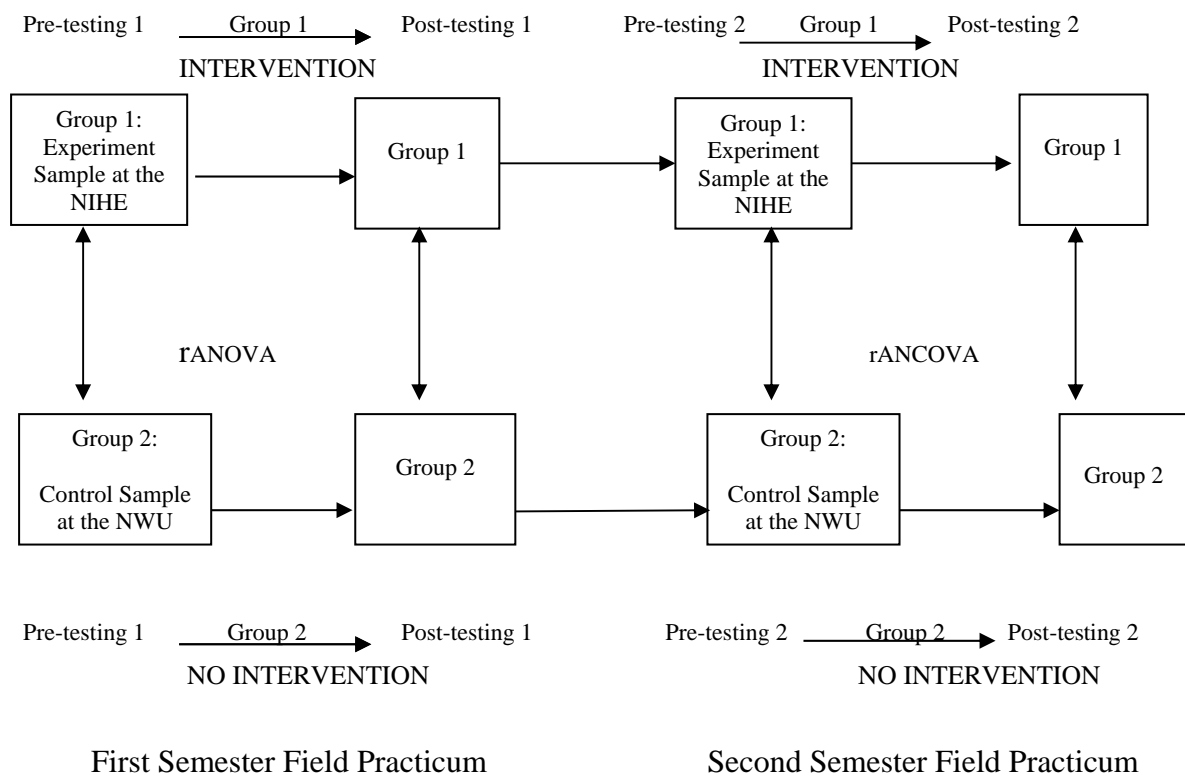


Figure 5.3: Statistical Algorithm for Quantitative Measurement of the Concerns variable

Of equal importance too, was the *practical significance of the differences*. Here Cohen's *d*-value was computed to detect whether the Effect Sizes (ES) of differences in responses between the groups was of practical significance.

According to Cohen (1988:10), “ES refers to the degree to which the phenomenon under study is manifested”. Cohen recommends the following conventional frame of reference (modified to include range values) for the ES Index (p. 25-27):

- $d < 0,2$: insignificant differences
- $0,2 \leq d < 0,5$: differences with small effect
- $0,5 \leq d < 0,8$: differences with medium effect and possibly of practical significance
- $d \geq 0,8$: differences of large effect and of practical significance.

Validity and Reliability of the measuring quantitative instruments

Defining Validity: Validity refers to the quality of a data gathering instrument that enables it to measure what it is supposed to measure. *Internal Validity:* the extent to which causal conclusions can be drawn. *External Validity:* applicability of the results and research findings to a wider environment. To prevent jeopardising the construct validity for this research, care was taken to counteract the possible emergence of the *Hawthorne Effect* (refers to the change(s) in behaviour or responses of the participants if they become aware of the research questions) by minimising special attention given to research participants, to ensure that the reason behind the design of the questionnaires remained anonymous and that the research questions were not known to the participating samples of respondents. For assessing the content validity of the *SCQ*, that is, the extent to which the *concerns* variable reflected a specific domain of content (*concerns theory*), the questionnaire was field-tested using the pilot sample identified earlier in this chapter, and revised on the basis of information gathered from the piloting process. To validate the *SCQ* was to ensure that it measured the intended concerns rather than other unintended concerns. It could also help in reducing measurement error.

Defining Reliability: Reliability is the extent to which the obtained scores may be generalised to different measuring occasions and also refers to the degree of consistency that the instrument demonstrates. The sub-scale reliability of the *SCQ* also needed to be addressed. *Cronbach's alpha coefficients* were used to measure the internal-consistency reliability of these sub-scales within the *SCQ* (see Table 5.1).

This index showed the degree to which all the categorised items of concerns measured the same sub-scale. Sub-scales with Cronbach's Alpha values of less than 0,5 were discarded from further statistical analysis in this study because of their unreliability (see Nunnally, 1978:295). Assistance in data computation and analyses was secured from the Statistical Consultation Services of the North-West University (Potchefstroom) under the supervision of an appointed statistical consultant.

5.2.4 Research Methodology

The research methodology process refers to how the research is conducted and includes subsidiary sections such as the literature study, sampling, measurement, data collection, data analyses and interpretation. Before the commencement of the empirical study, the *ABEV* and the *SCQ* questionnaires were piloted by this researcher with the UWC sample group identified earlier. Based on the comments and statements of this pilot sample, the necessary adjustments to the *ABEV* and *SCQ* questionnaire were effected before implementation. The researcher prepared and delivered letters of invitation to the relevant authorities asking for permission for student teachers to participate in this study and for access to placement schools (see Appendices D, E and F). The study population was addressed by the researcher at both the NIHE site and the NWU campus for obtaining their permission to participate in the study. The brief included informing student teachers about making informed choices as to whether they want to participate voluntarily in the research. The researcher assured these prospective participants of the parameters of confidentiality, by guaranteeing confidentiality during the scoring/completion of the questionnaires and interview sessions. The student teachers were informed (if they had decided to participate) not to write their names on the questionnaires to ensure that their ratings and responses were treated confidentially. They were also informed about the study and its relation to their (student teachers') field and more specifically their programme of study. Furthermore, the information session also outlined the purpose and possible potential value of the research.

Coded questionnaires (*inductive* and *a priori* coding) were used to distinguish between the responses from the two groups. The interviewing process took place at the NIHE site and transcripts of the responses are in the possession of the researcher.

The researcher was solely responsible for administering the *ABEV questionnaire* and conducting the interviews at the NIHE site. Assistance for the dissemination and collection of the *SCQ questionnaire* at the NWU (Potchefstroom campus) was provided by some Mathematics colleagues from the Faculty of Education Sciences.

5.2.4.1 Scoring and coding the questionnaire

The administration of the *ABEV* questionnaire (see Appendix A) was done at institutional level (at the NIHE site). All the respondents from Group 1 ($n = 40$) were given sufficient time to complete the open-ended questionnaire (see paragraph 5.2.4 on the issue of confidentiality). The affect items were structured on the questionnaire and coding was done by analysing student teachers' responses (by focusing on key words and phrases) and then categorising these accordingly, using codes developed when examining the written responses of the participants.

The interviewing process took place at institutional level (also at the NIHE site) after each of the field practicum sessions, as part of the feedback sessions (subject-specific feedback) normally conducted to elicit problems or any other issues student teachers might have experienced during field training. An interview guide was used to probe how Mathematics student teachers experienced the use of learning packages in their examination, interpretation and teaching of topical issues and newsworthy events. All participants from Group 1 ($n = 40$) were interviewed. Transcriptions of their (Group 1) verbal responses were done. The notes of the transcripts were reviewed against the tape for purposes of content accuracy. Coding was done by analysing student teachers' verbal responses (by focussing on key words and phrases) and then categorising these accordingly using codes developed when examining their verbal responses.

During data analyses, the transcripts were re-read and the important sections labelled to indicate their importance. The data were examined and analysed (against the quantitative findings of the concerns questionnaire) to ascertain whether or not the use of learning packages may have ameliorated the concerns of Mathematics student teachers during the field practicum sessions.

Coding of the *Interview Guide* (see Appendix B) was done to reflect the session (1st or 2nd field practicum session) and the time (post field practicum session) when the interviews were conducted. The questions on the interview guide (both open-ended and closed-ended) remained the same and no modifications were made except in the coding of the *Interview Guide*. Retaining the same questions on the *Interview Guide* for both field practicum sessions allowed the researcher to detect any verbal perturbations in expressions and perceptions that might be linked to changes in the concerns of the student teachers (from Group 1) as a direct consequence of the intervention strategy (using the learning packages).

With regard to the SCQ (see Appendix C), it was distributed at different stages of student teaching experiences as part of their field training in 2011 and was duly scored. This questionnaire was administered to both the experimental sample (Group 1) and the control sample (Group 2) in a pre-test and post-test format during each of the two field practicum sessions of 2011 (see Figure 5.3). The SCQ consisted of 15 items with five items on each of the self, task and impact sub-scales. The items on the SCQ were deliberately scrambled so that the respondents were unable to detect any categorisation of these items within the sub-scales of *self*, *task* and *impact*. Table 5.1 depicts the categorisation of the “scrambled” concerns items as per sub-scales of *self*, *task* and *impact*.

Table 5.1: Sub-scales for the Categorisation of Concerns Items

Concerns sub-scales	Items				
SELF CONCERNS	3	6	9	12	15
TASK CONCERNS	2	4	7	10	13
IMPACT CONCERNS	1	5	8	11	14

The coding on the SCQ questionnaire over the two sessions of field practicum was as follows:

NIHE-SCQ = Administered to student teachers at the NIHE (Experimental group-Group 1)

NWU-SCQ = Administered to student teachers at the NWU (Control group-Group 2)

Session **1** = First practice teaching session

Time **Pr** = Pre-test Code: **1/Pr/NIHE** and **1/Pr/NWU**

Session **1** = First practice teaching session

Time **Po** = Post-test Code: **1/Po/NIHE** and **1/Po/NWU**

Session **2** = Second practice teaching session

Time **Pr** = Pre-test Code: **2/Pr/NIHE** and **2/Pr/NWU**

Session **2** = Second practice teaching session

Time **Po** = Post-test Code: **2/Po/NIHE** and **2/Po/NWU**

5.2.4.2 *Limitations on conducting the empirical investigation*

The following limitations were anticipated when the empirical investigation commenced:

- It might have been possible that some respondents may have been somewhat ambivalent about completing the SCQ, notwithstanding the assurance given to them with respect to anonymity and confidentiality.
- It might have been possible that student teachers may have felt “uncomfortable” in expressing any concerns which might reflect on the teacher-training programmes (at both the NIHE site and the NWU (Potchefstroom campus)).
- The size of the experimental sample was limited to 40 respondents. The limitation was inherent in the mathematics programme as annual enrolment of Mathematics student teachers at the NIHE site is becoming a matter of concern.

Notwithstanding these limitations, the researcher has reason to believe that the varying size of the respondents groups (both experimental and control) are representative enough of a cross-section of Mathematics student teachers at both the NIHE site and the Potchefstroom campus. Furthermore, the consistency and pervasiveness of the data throughout the study give reason to believe that the findings can be generalised to those who have participated in this study.

5.3 CONCLUSION

This chapter considered the parameters of the empirical investigation with regard to its research design and methodology. The finer details of the research design and methodology were presented. Figure 5.1 provided an expositional framework for the empirical investigation from both a qualitative and quantitative orientation. In the next chapter, an exposition of the processed data, both qualitative and quantitative are presented and analysed. The results from the interpretation of the data are done, both from a specific and general perspective.

CHAPTER 6

ANALYSIS AND INTERPRETATION OF THE DATA

6.1 INTRODUCTION

The focus of this chapter was on the analysis of the processed data. The typology of the study was qualitative (narrative) in nature where the research design incorporated aspects of quantitative (descriptive) research. In its entirety, this research design took on a mixed-mode of inquiry illustrated by the quan + QUAL typology (see paragraph 5.2.1). According to McMillan and Schumacher (2001:428-429) a mixed-mode approach enhances the validity and credibility of a study. Qualitative research serves as an adjunct to those studies which are more quantitative in nature. This study has three data sets (two qualitative and one quantitative), with inferences being made from all three sets of data in relation to the findings and recommendations. Since the qualitative analyses are not restricted in the same way as the quantitative analysis is to a set of numerical data, the data for qualitative analyses are narrative in nature and can produce a corpus that renders credibility and trustworthiness to the study. The protocol for reporting the results from both the qualitative and quantitative investigation is outlined in the schema of Figure 6.1.

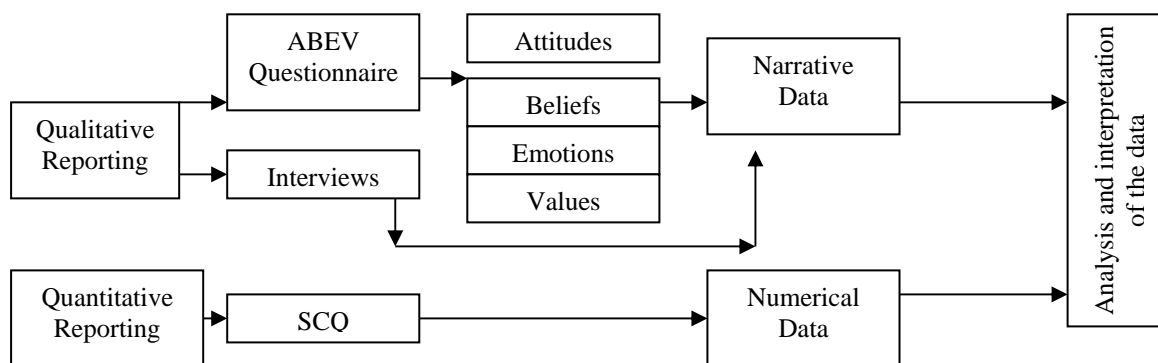


Figure 6.1: Schema for Chapter 6

6.2 ANALYSES OF THE QUALITATIVE DATA

The qualitative reporting in this chapter was focused on two qualitative measurements:

- *The scoring of the ABEV questionnaire.*
- *Interviewing Mathematics student teachers on their examination, interpretation and teaching of topical issues and newsworthy events when using learning packages.*

6.2.1 The Results from the ABEV Questionnaire

The perceptions of Group 1 (experimental group) were elicited to determine how affect influenced the learning of Mathematics. The affect variables used were the following:

- *attitudes towards mathematics;*
- *beliefs about mathematics;*
- *emotional reactions towards mathematics; and*
- *values about mathematics.*

6.2.1.1 *Qualitative data for attitude towards mathematics*

Responses to the first affect variable *attitudes towards mathematics* were captured and categorised as per item⁶. As *attitudes towards mathematics* cannot be directly observed, they are mostly inferred from behaviour, usually in the form of verbal responses or observable actions during the learning of mathematics. In this study, the participating student teachers noted their attitudinal dispositions through written responses. The following key responses are presented in this paragraph for analyses.

⁶ All narrative data for the qualitative analysis in paragraphs 6.2.1.1, 6.2.1.2, 6.2.1.3 and 6.2.1.4 are presented in Appendix J.

To ascertain student teachers' attitudes towards the importance of mathematical content knowledge and mathematical didactical knowledge, 38% of the respondents noted that the learning of mathematical content was important. A percentage score of 31% was noted for didactics, as well as for both content and didactics. In other words, there was no significant disparity in the dispositions of respondents towards content knowledge and pedagogical content knowledge. To detect any attitudinal dispositions to any branch of Mathematics, 41% of the respondents noted Trigonometry as a topic that they were least confident to teach. Abstract Mathematics was viewed by respondents as textbook and more procedural-based while contextualised mathematics was viewed by others as requiring more in-depth thinking skills about real-world problems and was more context-orientated. Respondents (72%) acknowledged that their attitudes towards mathematics had changed since being at university, citing reasons that it was more comprehensive and in-depth, and that learning Mathematics required more effort than school mathematics. A few of the respondents agreed to the sentiment that a positive attitude towards mathematics can lead to the enjoyment and less frustration towards learning and doing Mathematics and possibly leading to an increased level of confidence towards doing well in Mathematics (see Appendix J: items 9 & 10). The preceding narrative data could be triangulated with the statement by Snyders (2008:236) who stated (*in the negative*) that learners who do not have a belief in being successful in Mathematics, do not have a good chance of doing well, and with the view of Ernest (1988: 290) who referred to a positive attitude towards mathematics as a combination of the degree of students' liking of the subject and confidence in their mathematical ability.

At field practicum level, some of the respondents expressed their concerns about their teaching abilities with attitudinal dispositions varying from low confidence levels to their abilities to perform in order to meet the needs of their learners. The impact that some of these student teachers wanted to have on their learners during field practicum was for them (learners) to develop a positive attitude towards the learning of Mathematics by changing their mindset and perceptions of Mathematics (see Appendix J: item 4). The NIHE mathematics lesson plan elicited a 38% response score in favour of using it, with a substantial amount of participating student teachers (34%) not responding to this question. 53% of the respondents found that the use of social context learning packages in a mathematics lesson had made it easier for learners to understand the notion of real-life context as these learners were able to relate their personal views to what was happening in

the world. The difficulties noted in using these learning packages were that it was time consuming, that the context (global) was sometimes unfamiliar to the learners and that the content of the learning packages was not always linked (theme-wise) to the lesson topic that had to be taught.

6.2.1.2 *Qualitative data for beliefs about mathematics*

Liljedahl (2005:221) posits that *beliefs about mathematics* were often based on learners' own experiences with Mathematics while Evans and Zan (2006:44) contend that learners' mathematics-related beliefs together with their mathematical knowledge, underlie learners' understanding of and functioning in the mathematics classroom. However, learners' beliefs about their learning of Mathematics and their abilities to do Mathematics do change as they grow older. As many researchers have pointed out, learning and success in Mathematics are influenced by learner beliefs about mathematics and about themselves as Mathematics learners (see Hannula, *et al.*, (2004); Leder & Forgasz, (2002); Schoenfeld, (1992)). In response to item 12 on the ABEV questionnaire, respondents noted that learners' repeated negative emotions towards mathematics could lead to these learners becoming less committed and anxious towards the subject that could possibly lead to the manifestation of fear and low self-esteem. According to Liljedahl (2005:222), repeated negative experiences will eventually produce negative beliefs and attitudes, and likewise, repeated positive experiences will produce positive beliefs and attitudes. In addition, 63% of the respondents disagreed with the common belief that low achievement in Mathematics can be blamed on low socio-economic status, unwillingness to learn or personal disabilities, with some stating that "external circumstances can have little impact on a desire or willingness to succeed in life".

In addressing the perceptions held on the nature of Mathematics, the classical belief of it being mechanistic and structural (instrumentalist view/aspect of scheme – see paragraph 2.8.2.2) received 31% support whereas 69% of respondents believed contemporary Mathematics to be much more and supported the view of mathematical application to varied contexts (problem-solving view/aspects of application and process) (also see Kaiser (2006: 394) on the classification system of mathematical beliefs).

All 32 participating student teachers agreed that their experiences with Mathematics helped shaped their beliefs about mathematics whereas 69% of the student teachers agreed that many teachers' beliefs and views seemed to be shaped by their (teachers') experiences in the classroom. According to Chapman (2001:233), some teachers believed that they had a strong influence on the beliefs of their learners however Eichler (2006:17) notes that research has as yet yielded few results which facilitated the understanding of the relations between teachers' and learners' beliefs. Teachers are definitely viewed by some respondents as being role models whose actions and beliefs are sometimes imitated by their learners.

An even distribution of responding student teachers (50%) believed that they have/have not received adequate training in the NCS and/or the CAPS curricula. Analysis of the narrative data revealed that most of the respondents agreed that understanding the emotional state of learners could give them some insight into their (learners) mindset and beliefs, and that the learners' emotional strengths and weaknesses can influence their belief systems. According to Evans and Zan (2006:44), given the close relation between beliefs and emotions, investigation of learners' emotions could enhance better understanding of learners' beliefs.

6.2.1.3 Qualitative data for emotional reactions towards mathematics

Emotions are the least stable of affect constructs and have received little attention in the role it plays in the learning of Mathematics. The role of emotions when learning Mathematics, according to Op't Eynde (2004:121), necessarily implies viewing emotions as consisting of multiple component systems that regulate one another in a specific context, for instance the mathematics classroom (task-related, see Table 2.3); and viewing learning as an engagement in the practices of a specific community that maintains the person's interpersonal relations and identity in a particular social context (social-related). When addressing items 21 and 27 (see Appendix J), 94% of respondents expressed a perception of experiencing a varied number of emotions when learning and doing Mathematics. Their reasons ranged from initially experiencing emotional changes from feeling frustrated to experiencing satisfaction when accomplishing the tasks. Respondents expressed intense emotions at the beginning and less intense emotions at the end of an assignment or a mathematical task. It appeared that the degree of difficulty of Mathematics could make a varied number of emotions come to the

fore with 94% of the respondents expressing their perceptions of experiencing a range of emotions (see Appendix J: item 27, also see Op't Eynde (2004:121)). For 50% of the respondents the most intense emotions were experienced when they worried about whether learners have learnt what they (student teachers) had taught them (impact-concerned). Only 9% of respondents expressed their most intense emotions when thinking about their own abilities when doing Mathematics (self-concerned).

The emotions experienced by respondents when using the learning packages ranged from being overwhelmed and apprehensive to some form of excitement about the prospect of using it in their mathematics lessons. Once more, the perception of time spent on using learning packages came to the fore: "I was stressed as I knew that using the learning packages in my lesson would be time consuming as my lesson period was only 30 minutes." The practice of mathematising topical issues and newsworthy events during the second session of field practicum (for Group 1) elicited an overwhelming number of negative emotions from the respondents. Emotions of feeling extremely challenged, anxious and frustrated were indicative of the range of difficulties experienced by the participating student teachers when embarking on a task they may have been uncertain about or uncomfortable with.

In qualitatively analysing the data in Table 6.1, the polarities (+/-) of the emotional constructs were reflected in the descriptions of the emotions attached to each of the statements (also see Table 2.3). The data revealed that a number of respondents (81%) enjoyed engaging in mathematical tasks or assignments while only 19% of the respondents expressed their boredom towards this item. A negative-oriented emotional state (anxiety) was expressed for "*When waiting to write a Mathematics class test*" with 66% of participating student teachers scoring this item. The item "*When receiving the results of a Mathematics test*" were scored against the emotional states relief (+) and sadness (-), with 31% of respondents not being happy with their Mathematics test results. Fortunately, according to Liljedahl (2005:221), emotions are rooted more in the immediacy of a situation (*such as receiving test results*) and as such are often fleeting.

Scholarly discontentment was noted in the expressions of the respondents when addressing the acknowledgement of mathematical achievements. The scoring of the emotional state of contempt noted 12/32 respondents expressing their dissatisfaction with the notion of norm-referenced evaluation.

Table 6.1: Tallying Student Teachers' Emotional Reactions to certain Mathematical Situations

Statement	Emotion Construct	Scoring
	Description of the emotion	%
23. <i>When busy with mathematical assignments or tasks.</i>	Enjoyment:	26/32=81%
	Boredom	6/32=19%
24. <i>When waiting to write a Mathematics classtest.</i>	Anxiety	21/32=66%
	Hope	11/32=34%
25. <i>When receiving the results of a Mathematics test.</i>	Relief	21/32=66%
	Sadness	10/32=31%
	No responses to this question	1/32=3%
26. <i>When a mathematics award is made to your fellow student, how do you feel knowing that you have also worked as hard or even harder than that student in Mathematics?</i>	Contempt	12/32=38%
	Admiration	19/32=59%
	No responses to this question	1/32=3%

6.2.1.4 *Qualitative data for values about mathematics*

Schunk (2004:384) posits that values have a direct link to achievement behaviours such as persistence, choice and performance and might relate positively to many self-regulatory processes such as self-observation, self-evaluation and goal setting. In addressing the link between personal values and achievement, 94% of the respondents acknowledged that such a link does exist, citing that a person with good values has good attitudes and work ethics that could lead to a high level of achievement. Respondents also noted that good values could be a source of motivation to do well (see Appendix J: item 30). When asked to identify *values about self* (values students think they have in order to be successful in Mathematics – see Table 2.4), the responses featured notions of self-confidence, self-respect, self-esteem, integrity, self-belief and self-actualisation (see Appendix J: item 31). *Values about task* (values students possess in order to complete a mathematical task successfully), featured notions of being goal-orientated, perseverance, hard work, commitment, endurance and motivation (see Appendix J: item 32). Judging from the responses, it appeared that item 33 posed some difficulty in answering. One significant response that captured the essence of item 33 was defining *beliefs about mathematics* as pre-existing notions about Mathematics and *values about mathematics* as promoting good morals and ethics when dealing with Mathematics.

In Table 6.2 the responses of the participating student teachers are noted for the two value constructs in relation to the learning of Mathematics. It was noted in the analyses of responses, that most of the respondents were willing to attach values to Mathematics since they viewed Mathematics as a conduit to transfer values to their learners and that the “nature of Mathematics can serve as a value-system that deals with how to cope with problems in real life and how to solve these problems” (see Appendix J: 38). Further results showed that the respondents perceived their values as less-focused on their survival in the classroom (19%) and more on their mathematical task and what impact they may have on their learners (31% and 50% respectively).

When engaging in the use of learning packages, the values some respondents wished to impart to their learners were an awareness of what was happening in the world, to be critical and not be neutral to social, political, economic, etc. upheavals in the world, to be able to

accommodate other people's views on events, to develop a level of empathy and sympathy with people caught up in situations and to show respect and understanding to other citizens of the world by promoting good social values.

Table 6.2: Values Constructs in Relation to the Learning of Mathematics

Values constructs in relation to the learning of Mathematics		
<i>Variable</i>	<i>Predictor</i>	Mathematics Example (Responses noted below)
<i>Values about self</i>	<i>Integrity</i>	Maths teacher is fair/teacher is well-prepared for lesson/to perform at the best of my ability/to be committed towards my learners/to be professional in my approach.
	<i>Sensitivity</i>	Accept learners' limitations/be patient with struggling learners/be considerate in my interaction with learners/to become aware and accommodate the different needs of my learners.
<i>Values about task</i>	<i>Perseverance</i>	To endeavour to complete my work/to always persevere/persist with what I am doing until I succeed/to be dedicated in helping learners until they understand the work.
	<i>Satisfaction</i>	Express my joy when completing a maths task or assignment/to observe learners doing well/getting good results from learners/putting effort into tasks and succeeding.

Hill (2008:102) avers that “it is imperative for teachers to acknowledge that they teach values in the course of everything they do, from the moment they engage with the school culture”. In addition, Nieuwoudt and Golightly (2006:111) state that “the teacher should be in command of relevant content and pedagogical knowledge and in possession of those skills and dispositions needed to purposefully and meaningfully facilitate the learning, and to be equipped with a value system worthy of stewardship education”.

6.2.2 The Results from the Interviews

The perceptions of the Mathematics student teachers from Group 1 about their examination, interpretation and teaching of topical issues and newsworthy events when using learning packages during field practicum sessions were elicited using semi-structured interviews. The following qualitative report focused on the core responses of participants by highlighting key words or phrases within the context of the questions posed (see Appendix B) during the interview process that took place after session 1 and session 2 of the field practicum. For purposes of qualitative reporting, no differentiation in the responses between session 1 and session 2 was made, since there was no need for longitudinal qualitative inferences as the focus of the interviews was on the perceptions of the respondents towards the use of social context learning packages.

Statement 1: *Comment on your understanding and interpretation of traditional word problems, contextualised problems and social context problems.*

The rationale for posing this question was to ascertain whether the respondents could make the distinction between context-free mathematical problems and contextual mathematical problems. Ultimately the use of social context learning packages was to make student teachers aware of real-time topical issues and newsworthy events by encouraging their learners to solve non-routine problems in a variety of situations defined in terms of social functions (such as the social context).

The core responses to this statement were:

Traditional word problems: ... *“deal with basic content and there is no context”* ... *“these problems are very teacher-orientated”* ... *“situations which are not familiar to real-life”* ... *“more on calculations and less on context”*... *“an old approach to problem-solving”* ... *“using simple context”* ... *“common word problems with no context”*.

Contextualised word problems: ... *“more appropriate to real-life”* ... *“gives a broader view of what is happening in the world”* ... *“context link to real-life”* ... *“(mathematics) textbooks provide a more wider variety of contextual problems”* ... *“help with higher levels of thinking skills”* ... *“mathematics taken out of the classroom and into the outside environment”* ... *“ensure that learners are familiar with the environment”* ... *“content placed in context”* ... *“the use of different context such as environmental, social, physical, etc.”* ... *“deals with advanced mathematics in more complex situations”*.

Social context problems: ... *“gives a sense of what is happening in the world”* ... *“deals with social factors”* ... *“allows one to debate issues dealing with real-life problems”* ... *“using context and make it relevant to situations”* ... *“events in news/media that is applied to mathematics”* ... *“events in the world captured in learning packages”* ... *“what happens in our lives”* ... *“focus is more on relevant real-life issues”* ... *“learning packages are used in classrooms and deal with outside situations or events”* ... *“provide more in-depth knowledge of the context”*.

By collating the perceptions of the respondents, it was evident from their answers that respondents could discern between context-free and contextualised word problems (findings). Some of the qualitative data (the responses) could be triangulated with the findings and with the literature study (see Figure 5.2). For instance, *“help with higher levels of thinking skills”* showed a predisposition of student responses towards the sentiment of Goldin (2002b:200), who posits that learners who engaged in real-life, contextualised and open-ended problem-solving, are involved with high-order mathematical reasoning processes.

Carraher, Carraher, and Schliemann (2004:187) state that performance on mathematical problems embedded in real-life contexts was superior to that of context-free computational problems (compared with: *“deals with advanced mathematics in more complex situations”*). Furthermore, a sense of purposefulness in the use of contextualisation, interpreted from the responses, could possibly allude to the fact that even though context-free or abstract Mathematics are valued for their power, contextualised mathematics is valued for its meaningfulness and relevance (as stated by Goldin, 2008:189-190). In recent years, there has been increasing interest in exploring social contextual factors both within and outside of the classroom to *“provide more in-depth knowledge of the context”*.

Learning within such social context environments can stimulate and enable learners to engage responsibly in quantitative and qualitative arguments relating to social issues at local, national and global levels (*“allow one to debate issues dealing with real-life problems”*).

Question 1: *Was the use of learning packages during the field practicum sessions of concern to you?*

Core responses varied from: ... *“The context of the learning packages was not suitable to some of my learners”* ... *“My concern was that it was difficult to link concept to context”* ... *“learning packages tend to confuse learners – not sure when to apply the learning packages”* ... *“my concern was that I was unable to link the content of the learning packages to the theme of my lesson I had to present during teaching practice”* ... *“learning packages were taught in isolation of my mathematics lesson”* ... *“I was very anxious to use the learning packages”* ... *“learners were not familiar with what was happening in the world and it made my task difficult in explaining to them how real-world events can be used in mathematics”* ... *“I had a lot of work to do and the learning packages brought in additional work that I had to cover during my mathematics lessons”* ... *“my concern was how learners would cope with the learning packages”* ... *“I am not used to using learning packages in my lessons”* ... *“difficulties I experienced in designing my own learning packages”*.

The above responses to the use of learning packages revealed a skewed orientation towards the difficulties in implementing and interpreting the social context learning packages during field practicum. This prompted the researcher to pose a follow-up question to ascertain what the respondents were specifically concerned about. The respondents verbalised their concerns about their not being able to properly use these learning packages, as the social context nature of these packages were new to them: *“my concern was that I was unable to link the content of the learning packages to the theme of my lesson I had to present during teaching practice”* and the fact that: *“I (student teacher) was very anxious to use the learning packages”*. Another concern highlighted by respondents was that concept formations and concept developments promoted by these learning packages were not easily identifiable: *“The context of the learning packages was not suitable to some of my learners.”* Analyses of the verbal data also noted that respondents expressed their concerns about learners experiencing difficulties in using these learning packages and those that had, highlighted

language and comprehension issues as possible limitations: “*learners were not familiar with what was happening in the world and it made my task difficult in explaining to them how real-world events can be used in mathematics*”.

All the respondents expressed their difficulties in designing their own learning packages during session 2 of the field practicum. This decline in confidence in the respondents’ abilities to design their own learning packages (concerns dealing with self), and whether their learning packages were appropriate for use by their learners (concerns dealing with learners), was supported by the statistical results in Figure 6.2 and Figure 6.3. Blomhøj and Jensen (2003:128) note “the difficulties students have in learning the game of mathematical modelling, especially of real-world issues and events”. Even though CAPS: Mathematical Literacy (DBE, 2011b:7) promotes the exploration and the solving of real-world problems, it is essential that the contexts that learners are exposed to are authentic and relevant, and relate to daily life, the workplace and wider social, political and global environments. It is within this framework that the learning packages were used in the intervention strategy because of its real-time ontic nature, and was primarily targeted at the amelioration of student teachers’ concerns when engaging in contextualised mathematics.

In addressing unfamiliar contexts (“*The context of the learning packages was not suitable to some of my learners*”), it is unrealistic to expect that learners will always be exposed to contexts that are specifically relevant to their lives (DBE, 2011b:8). However, it has been noted that barriers to understanding contextualised mathematics were rooted in language and in reading and comprehension skills which could have resulted in learners finding contextualised problems much more difficult than context-free mathematical problems (also see Murray, 2003:40).

Statement 2: *Comment on the suitability of using social context learning packages in South African mathematics classrooms.*

Core responses varied from: ... “*using learning packages are fine, designing them may be a problem*” ... “*learning packages can be used to introduce real-life situations into the classroom*” ... “*can help in changing attitudes towards mathematics*” ... “*can be used as a*

form of diagnostic assessment” ... “can use learning packages at selected times” ... “can assist learners in developing problem-solving skills” ... “learning packages can be used once or twice per week in a mathematics lesson” ... “can assist learners to understand reality” ... “can help to benefit the study of mathematics”.

Analyses of the verbal data revealed that the participating student teachers agreed to using learning packages as part of a mathematics lesson. However, the time spent on its design still posed a significant problem for some participants. The use of learning packages at “selected times” (participant’s suggestion) could point to the notion that the learning packages should be designed as self-instructional and self-paced learning systems that will allow learners to achieve outcomes by monitoring and reflecting on the unfolding of events in real-time, over a designated period, and at the same time engaging in the Mathematics coherent to these events. These learning packages should be developed within the curriculum design ambit to address, among others, improving the quality of learning support materials, as well as to allow teachers much more flexibility to become innovative and creative in using learning repositories in their approaches towards teaching Mathematics. A possible solution to the design of learning packages is the recommendation made in paragraph 7.3.3 of a webpage to host the upload of social context learning packages, and allowing learners, students, teachers or any institution access to download these packages for use in any education setting or as part of Computer Assisted Instruction (CAI) or as Computer Assisted Learning (CAL) tools.

6.3 ANALYSES OF THE QUANTITATIVE DATA

The data preparation and the statistical processing of the raw data from the SCQs were done by the Statistical Consultation Services of the North-West University (Potchefstroom). The processed data received for analyses (albeit voluminous) was carefully selected and organised. The most needed data was extracted for the body of the analyses while the more extensive detail of the data was appropriately assigned to the appendix structure (see Appendices K, L, M and N). The quantitative reporting in this chapter focused on the following:

- Assessing the suitability of the respondent data for a factor analysis in this study – using the KMO and Bartlett’s tests.
- Using factor analysis to identify the clustering of items on the questionnaire within sub-scales (factors).
- The use of Cronbach’s alpha coefficients to measure the internal-consistency reliability of the factors.
- The use of repeated measures Analysis of Variance (rANOVA) to test the equality of means over time.
- The mean and standard deviation of items on the SCQ for reporting the concerns (as per item in a pre-post format) of student teachers during session 1 and session 2 of field practicum.
- Using Cohen’s *d*-value to detect whether the Effect Sizes (ES) of differences in responses between the groups was of practical significance.

6.3.1 Kaiser-Meyer-Olkin and Bartlett’s Tests

The results of the KMO and Bartlett’s Test are captured below (see Appendix K).

Correlation Matrix

Determinant = 0,002

If the determinant of the correlation matrix was equal to zero, there would have been computational problems with factor analysis. The determinant value computed for this study equalled 0,002 thus suggesting sufficient correlation of items.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,860
Bartlett's Test of Sphericity	Approx. Chi-Square	512,767
	df	105
	Sig.	0,000

The KMO measure was 0,860 and closer to 1 and showed an excellent value above the cut-off score of 0,5. For the Bartlett test, the significance (Sig.) was less than 0,05 and thus indicated that the items were correlated and formed part of some factors. Taken together, these tests provided the minimum standard which should be passed before a factor analysis could be conducted. The results for this study showed that a factor analysis of the SCQ could be performed and was done accordingly.

6.3.2 The Results of the Factor Analysis

In order to fully comprehend the data from a factor analysis, the following concepts in Appendix K are clarified:

- **Communalities:** It is the proportion of each item's variance that can be explained by the sub-scales (factors).
- **Factor matrix:** Contains the unrotated factor loadings, which are the correlations between the item and the sub-scale. Possible values ranges from -1 to +1. Low correlations of 0,3 or less are not statistically meaningful.
- **Structure matrix:** Represents the correlations between the variables (items) and the factors (sub-scales).
- **Pattern matrix:** Represents the linear combination of the variables and shows a map of the clustering of items around certain factors.
- **Factor correlation matrix:** Indicates the degree of correlation between the factors.

In interpreting the results from the pattern matrix, the data in Table 6.3 were analysed in terms of the factors around which the clustering of items occurred. The results showed the emergence of FOUR factors (sub-scales) explaining the percentage of variance accounted for by each factor (as opposed to the three sub-scales (Self, Task and Impact) used in the Fuller-Brown model). Clearly the data in Table 6.3, and using the information provided in Table 5.1, revealed that items 1; 4; 6; 7; 8; 11; 13 and 14 constituted *factor 1* and items 3; 9; 12 and 15 constituted *factor 2*. Only the first two factors were meaningful to be retained.

Factor 3 (item 2) and *factor 4* (items 5 and 10) were discarded on the basis of having an unacceptable value or having a low Cronbach's alpha coefficient (both factor 3's and factor 4's alpha coefficients were unacceptable – see Appendix N). (Note: The Cronbach's alpha coefficients were used to assess the internal-consistency reliability of the factors. Factors with Cronbach's α -values of less than 0,5 were discarded from further statistical analysis in this study because of their unreliability.)

Table 6.3: Pattern Matrix computed in Factor Analysis

Items on SCQ	Factor			
	1	2	3	4
scq13: Learners lacking the ability and skills to solve mathematical problems	0,764			
scq8: Diagnosing learners' mathematics problems during teaching practice	0,760			
scq7: Teaching an outcomes-based mathematics lesson	0,724			
scq11: Whether each learner is reaching his or her mathematics potential	0,692			
scq1: Meeting the needs of different kinds of mathematics learners	0,663			
scq6: Your ability to plan and prepare adequate mathematics lessons	0,587			
scq14: Being able to guide learners to construct their own solutions	0,530			
scq4: Being able to achieve the outcomes/goals of a mathematics lesson	0,499			
scq12: Losing the respect of your learners with regard to your teaching abilities		0,818		
scq15: Maintaining class control and discipline		0,623		
scq9: Being accepted and respected by other professional educators		0,317		
scq3: Doing well when being observed as you teach a mathematics lesson		0,292		
scq2: Working with too many mathematics learners each day			0,821	
scq10: Having too many non-teaching duties, for example photocopying, sports, etc.				0,564
scq5: Challenging unmotivated learners when teaching mathematics				0,350

Extraction Method: Principal Axis Factoring. / Rotation Method: Oblimin with Kaiser Normalization.

The three sub-scales of the Fuller-Brown model were modified on the basis of factor analysis to a two-factor solution for further use in data analyses. Table 6.4 represents the translation to a two-factor model.

Table 6.4: Translation to a Two-Factor Model for the Categorisation of Concerns Items

Fuller-Brown model of teacher development						Factor analysis: Two-factor model		
Concerns sub-scales	Items					Factor	Items	Cronbach's alpha coefficient
SELF CONCERNS	3	6	9	12	15	Factor 2 (Concerns about self-benefit)	3; 9; 12; 15	$\alpha = 0,69$
TASK CONCERNS	2	4	7	10	13	Factor 1 (Concerns about learner-benefit)	1; 4; 6; 7; 8; 11; 13; 14	$\alpha = 0,89$
IMPACT CONCERNS	1	5	8	11	14			

Task concerns dealt with the concerns about teaching, namely, the role of being a teacher, becoming an adequate teacher and being liked as a teacher, and impact concerns dealt with the needs of their (teacher's) learners (see paragraphs 3.5.2 & 3.5.3). These two concerns sub-scales were amalgamated (on the basis of factor analysis) to constitute *factor 1* which was now labelled as *concerns about learner-benefit* (see paragraph 3.3.1) since both task and impact concerns were focused directly or indirectly at benefiting the learners. *Factor 2* items related to the same focus as the items classified on the SCQ under the sub-scale self concerns, with the exception of item 6 "Your ability to plan and prepare adequate mathematics lessons." Evidently, this item was not a concern of self but of task or impact. The self concerns sub-scale included self-survival items that were now categorised for factor 2 as *concerns about self-benefit* (see paragraph 3.3.1). Student teachers were concerned with their own abilities. They worried about knowing the subject matter, anticipating problems, being allowed to fail, correcting when they do fail and being able to cope with being evaluated (see paragraph 3.3.1 - 1969).

The two-factor model of this study finds convergence with the earlier theoretical work of Fuller who identified two (*teaching*) phases that dealt with concerns with self-survival and about the needs of learners (see paragraph 3.3.1 – 1969). Hence, the Fuller and Brown model of teacher development, which represented a three-stage model that indicated a developmental sequence of concerns from self concerns → task concerns → impact concerns, was relegated in this study, based on empirical evidence, in favour of the two-teaching phases identified earlier by Fuller (1969) in the literature study.

6.3.3 The Results of repeated measure Analysis of Variance (rANOVA)

The use of repeated measures design for this study was based on several reasons. Firstly, the collection of data from the same respondents under repeated conditions helped eliminate or reduce individual differences as a source of between group differences. Secondly, even though the sample size for the experimental group (Group 1) [$n=40$] remained constant during all the measurements, the sample size of the control group (Group 2) declined during the two sessions of measurement (during field practicum). The population of Group 2 at the start of the investigation was $N=100$. Since participation in this study was voluntary, the number of respondents from Group 2 during session 1 was $n_1=49$ and during session 2 the number was $n_2=24$. Because sample members (from Group 2) were difficult to recruit, the advantage of using a repeated measures design was that it allowed statistical inferences to be made with fewer subjects or low sample sizes. The results from the rANOVA (see Appendix L: pre-analyses information for the categorisation of Task_Impact and for Social in terms of the two-factor model) are presented in Figure 6.2. As noted in paragraph 6.3.2, the Fuller-Brown model depicted a developmental sequence of concerns from self concerns → task concerns → impact concerns. The two-factor model in this study became focused only on the concerns about self-benefit and the concerns about learner-benefit. For the concerns dealing with learner-benefit, Figure 6.2 revealed a decline in the concerns from session 1 to session 2 for Group 1 (experimental group) while Group 2 (control group) showed a slight increase in the concerns going from session 1 into session 2. An analysis of the data from the rANOVA table (see Table 6.5) revealed the interaction effects between Group and Time (also see Figure 6.2) that measures whether Group and Time react differently in combination.

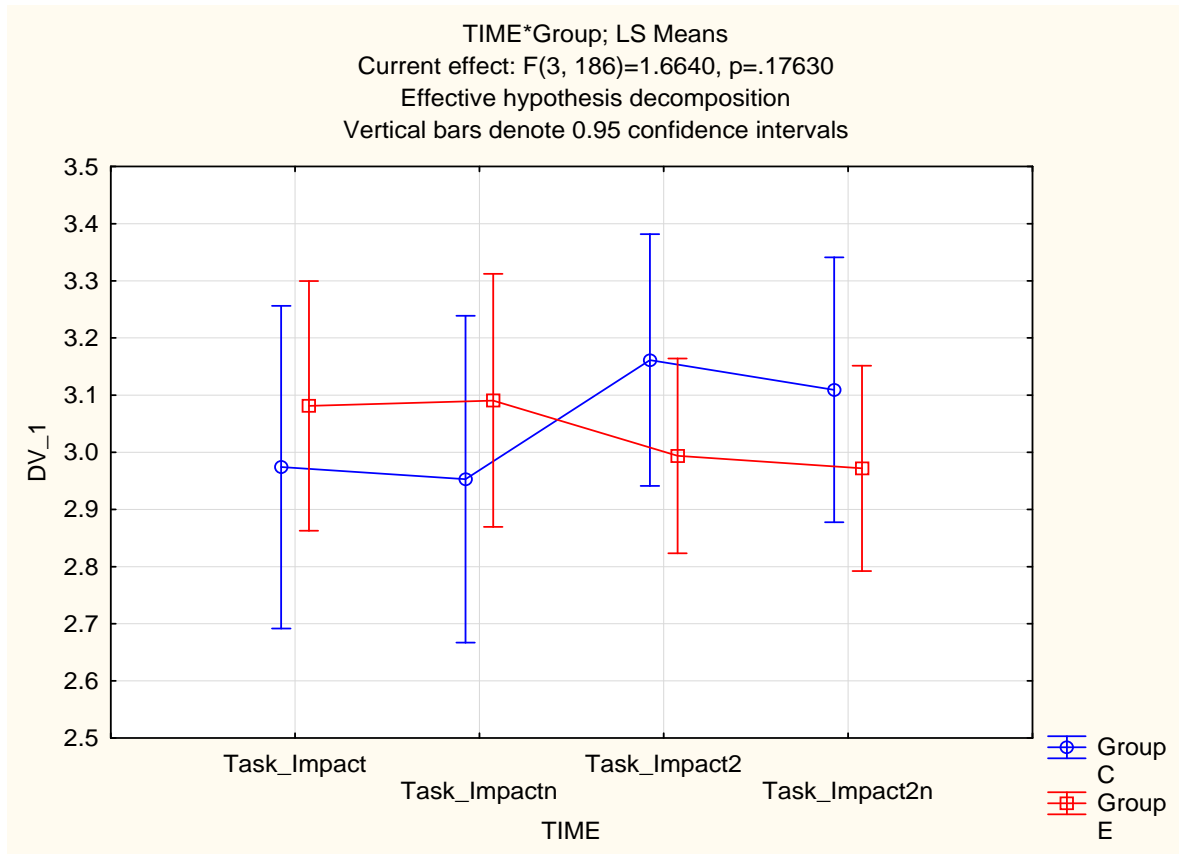


Figure 6.2: Measurements of Factor 1 (Concerns about Learner-benefit)

For interpretation purposes, the p-value for these rows measures the probability that the given data would result if there was no interaction effect. If the p-value is greater than 0.05 it is reasonable to assume that there is no interaction and only the main factors (Group and Time) are important.

Table 6.5: rANOVA for Factor 1 (Coded as Task_Impact)

Repeated Measures Analysis of Variance (Hassan 1)					
Sigma-restricted parameterization					
Effective hypothesis decomposition					
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	2220.797	1	2220.797	2488.345	0.000000
Group	0.014	1	0.014	0.015	0.901840
Error	55.334	62	0.892		
TIME	0.113	3	0.038	0.164	0.920734
TIME*Group	1.148	3	0.383	1.664	0.176300
Error	42.777	186	0.230		

Since the combination TIME*Group p-value is equal to 0,176, one could conclude that no statistical significant effects were found. (Note: Statistical significance refers to how likely an observed finding could have occurred by chance and indicates nothing of the magnitude of the effect observed. The Effect Size (ES) measures the magnitude of the treatment effect, see paragraph 6.3.4.) For the concerns dealing with self-benefit, Figure 6.3 reveals a similar pattern of decline and increase for Group 1 and Group 2 respectively.

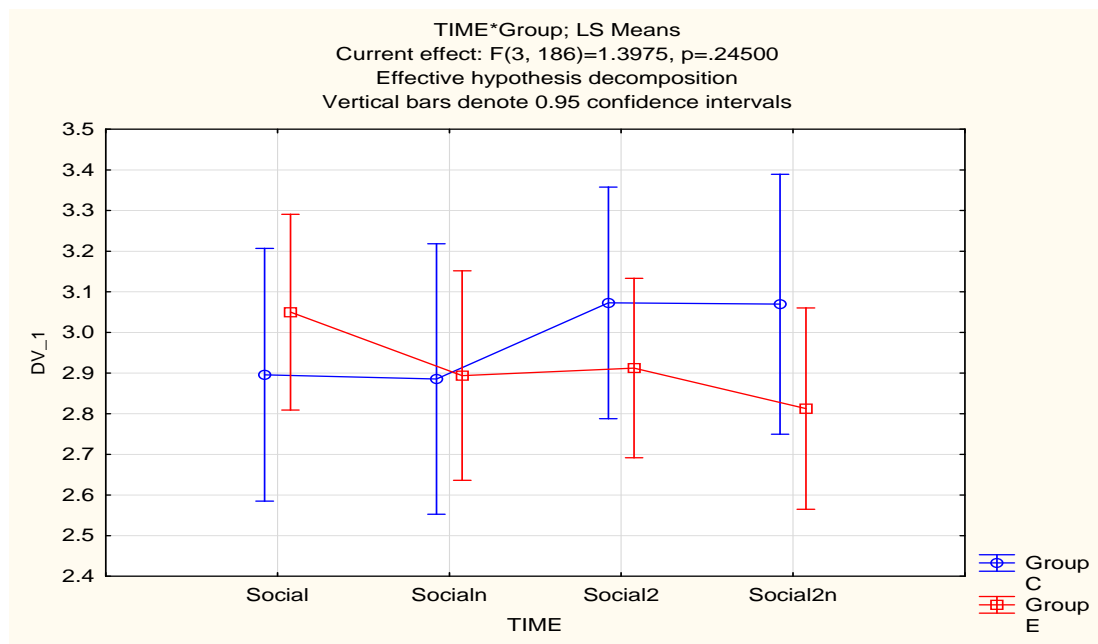


Figure 6.3: Measurements of Factor 2 (Concerns about Self-benefit)

The underlying assumptions for the decline in concerns for both self-benefit and learner-benefit for Group 1 should be interpreted in terms of the intervention which this group underwent. In Table 6.6, the combination TIME*Group p-value is equal to 0,245: one could conclude that no statistical significant effects were found. The use of social context learning packages during the intervention, based on the empirical data, seems to cause a decline in the concerns of both factors. Since sample members from Group 1 were issued with prepared learning packages for session 1 (see paragraph 4.2), it was expected that during session 2 this group should design their own learning packages for use during field practicum.

Table 6.6: rANOVA for Factor 2 (Coded as Social)

Effect	Repeated Measures Analysis of Variance (Hassan 1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	2087.248	1	2087.248	1629.185	0.000000
Group	0.244	1	0.244	0.190	0.664329
Error	79.432	62	1.281		
TIME	0.365	3	0.122	0.342	0.795033
TIME*Group	1.490	3	0.497	1.397	0.245002
Error	66.117	186	0.355		

The difficulties of allowing students to engage in the mathematical modelling of real-world issues and events are noted by Blomhøj and Jensen (2003:128), and they state that the formulation of problems, structuring complex situations and advancing critique of a mathematical modelling process, highlights the difficulties that students have in learning “the game of mathematical modelling”. Cognisance was taken of the fact that insufficient factual knowledge and insignificant experience with real-world phenomena often constituted obstacles for students’ active engagement in the design of their own mathematical modelling activities. The decline in confidence (see Figure 6.2 & Figure 6.3) suggested that Group 1 respondents might have doubted their ability (self-concerned) to design their own learning packages and whether their learning packages were suitable for intended use among their learners (concerns about learner-benefit).

6.3.4 The Results of Central Tendency and Effect Sizes

The use and comparison of basic descriptive data, such as the means and standard deviations, were necessary to make the results meaningful and to use them to initiate appropriate changes. According to Welman and Kruger (2004:209), without such comparative data the survey would have been of little or no use. The mean is considered the most commonly used measure of central tendency. The standard deviation, in turn, measures how the values fluctuate about the mean. The quantitative interpretation of the statistical data in Appendix M was made in accordance with a Likert-type scale used in this investigation.

Session 1: Group 1 responses (pre- and post-measurement)

The data from Appendix M showed that Group 1's pre-and post-measurement revealed mean scores that were very closely related. As a matter of fact, this group was moderately concerned about all the concerns items on the SCQ except for item 10: "Having too many non-teaching duties, for example photocopying, sports, etc." that they were very little concerned about. The small standard deviations (in relation to the span of the Likert-type scale) were indicative of homogeneous scoring among the average number of respondents. The Effect Sizes (ES) indicated insignificant differences over time.

Session 1: Group 2 responses (pre- and post-measurement)

Like Group 1, the scoring by Group 2 respondents showed the same pattern in their mean score per item in the pre-post measurement format. Similar to Group 1, respondents from the control group were moderately concerned with all the items on the SCQ except with item 2: "Working with too many mathematics learners each day." Interpretation of the data showed differences of insignificant effect for all pre-post item measurement except for item 10 which revealed differences with medium effect ($d=0,50$) and thus indicating an improvement over time with respect to this item (as the difference in their means in the pre-post measurements was positive).

Session 2: Group 1 responses (pre- and post-measurement)

The small standard deviations for the computed means (per item) for the pre-post measurements once again revealed the homogeneity in respondents' scoring. Interpreting the mean scores of items 2 and 10 in coherence with the Likert scale, indicated that respondents were very little concerned about the sentiments expressed in these two item statements. The difference in the means between the pre-post item measurements showed the ES index at the level of insignificant differences.

Session 2: Group 2 responses (pre- and post-measurement)

As in session 1, items 2 and 10 were rated as showing that the respondents were very little concerned. Again item 10 had an ES index ($d=0,65$) which indicated differences of medium effect, that is, difference in responses towards this item in the pre-post measurement were noticeable but not of practical significance. The ES value also indicated an improvement over time with respect to this item (as the difference in their means in the pre-post measurements was positive).

6.4 GENERAL DISCUSSION OF THE RESULTS

The dominance of cognitive theories in early research on education had relegated research on affect to a minimal. The reform views of Goldin (2002b:200), away from a traditional cognitive orientation, believed that learners should engage in real-life, contextualised and open-ended problem-solving, in which high order mathematical reasoning processes were central and universally accepted. The traditional epistemological view of the learning of Mathematics as being purely cognitive in nature need to be revisited, based on the evidence from this study that revealed how affect could influence the learning of Mathematics. Qualitative data (gathered from Group 1: experimental sample based at the NIHE) from the four affect variables, revealed students' expressions towards and about how their attitudes, beliefs, emotion and values can influence the manner they learn and do Mathematics. Of importance in interpreting the results from the ABEV questionnaire was the consideration of the polarities (+/-) of affect variables which revealed the orientations of the participants' expressions. For instance, in the attitudinal responses towards the learning of Mathematics, 38% of respondents rated the learning of mathematical content as important (+ orientation) while 41% of the same sample noted Trigonometry as a branch of Mathematics they were least confident about (- orientation). Respondents acknowledged that they experienced a change in their attitudes (72% - see Appendix J: item 2) towards the learning of Mathematics at university level citing reasons that Mathematics was "more comprehensive", "more in-depth" and "more effort required than school maths".

These narratives showed an acceptance by the respondents of their co-responsibilities towards their own learning (also see Nieuwoudt & Golightly, 2006:111-112). They also viewed the learning of *Abstract Mathematics* as text-book focused with limited learning resources while regarding *Contextualised Mathematics* as more meaningful and relevant, incorporating real-world problems (see Appendix J: item 7).

With regard to item 12 on Appendix J, regarding the belief of repeated negative emotions towards the learning of Mathematics, respondents noted the emerging emotions could negatively impact on the learning process, citing beliefs that learners might lose interest in wanting to do well in Mathematics, develop a low self-esteem and develop anxiety and a negative attitude towards the subject. Responses towards item 12 found convergence with the views of Liljedahl (2005:222) who notes that repeated negative experiences would eventually produce negative beliefs and attitudes, and likewise, repeated positive experiences will produce positive beliefs and attitudes. The belief that the learning of Mathematics usually involves mainly memorisation and following rules (see Appendix J: item 15), 69% of the respondents disagreed with this statement, citing reasons that “(learners) need to be exposed to application to context too and not just content memorisation”.

When addressing the item: *Describe the emotions you experience when doing Mathematics*, participants listed a number of emotions (see Appendix J: item 21). This narrative data concurred with the view of Op't Eynde (2004:121), when considering the role of emotions when learning Mathematics, who stated that emotions could be viewed as consisting of multiple component systems that regulated one another in a specific context. When considering the values needed when doing Mathematics (task-related), the responses (in terms of the predictor: perseverance) varied from: “to endeavour to complete my work” to “persist with what I am doing until I succeed”. For the predictor: satisfaction, the narratives ranged from: “express my joy when completing a maths task or assignment” to “putting effort into tasks and succeeding”. These two predictors that are related to the learning and doing of Mathematics could be triangulated with the views of Schunk (2004:384) who posits that values have a direct link to achievement behaviours such as persistence, choice and performance and might relate positively to many self-regulatory processes such as self-observation, self-evaluation and goal setting.

In sum, the influences of the above affect variables on the learning of Mathematics were reported upon and provide the necessary evidentiary data to place affect central to cognition. This view is supported by McLeod (1994:642) who recommends a more integrated approach to research on affect and cognition. To obtain optimal performance in the teaching and learning of Mathematics, researchers in mathematics education need to acknowledge the role and impact of affective issues and integrate it into studies of cognition. McLeod (1992:575) states that affective issues play a central role in Mathematics, and if learners are going to become competent learners of Mathematics, their affective responses to Mathematics are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low order mathematical skills.

The measurement of the concerns that Mathematics student teachers had during the two field practicum sessions were made quantitatively, and it involved Group 1 (experimental sample) and Group 2 (control sample). The SCQ consisted of the three concerns sub-scales used in the Fuller-Brown model and the concerns items were modified as was done by Reed (1995). Factor analysis showed the emergence of two statistically significant factors that dealt with the concerns about learner-benefit (factor 1) and the concerns about self-benefit (factor 2). The three sub-scales of the Fuller-Brown model were thus modified on the basis of factor analysis to a two-factor solution for further use in this study. Even though Group 1 underwent an intervention through the use of social context learning packages, the results revealed that for factor 1 a decline in the concerns from session 1 to session 2 occurred for Group 1 (experimental group) while Group 2 (control group) showed a slight increase in the concerns going from session 1 into session 2 (see Figure 6.2). For factor 2, Figure 6.3 reveals a similar pattern of decline and increase for Group 1 and Group 2 respectively. The use of social context learning packages during the intervention, based on the empirical data, seemed to cause a decline in the concerns of both factors for Group 1.

The decline in confidence may suggest that Group 1 respondents might have doubted their ability (concerns about self-benefit) to design their own learning packages and whether their learning packages were suitable for intended use among their learners (concerns about learner-benefit). The difficulties of allowing student teachers to engage in the mathematical modelling of real-world issues and events were noted by Blomhøj and Jensen (2003:128).

6.5 CONCLUSION

There is a growing interest in the mixed-mode approach to research in education, and this study helped promote such an approach. The use of qualitative measurements and interpretative techniques assisted in establishing the trustworthiness of the narrative data. Together with the quantitative measurements and statistical techniques, the validity and reliability of the numerical data were computed to establish how the quantitative approach could assist the results of this study. Measurements at institutional level focused on the influence of affect on the learning of Mathematics. Results from the qualitative data revealed the need to consider the role of affect in the learning and teaching functions. At field level, the concerns of student teachers were measured quantitatively and revealed that these student teachers indeed have numerous concerns with regard to their abilities and competencies as functional teachers. In the final chapter, the research questions are addressed based on the findings of this study and the necessary recommendations are put forward.

CHAPTER 7

SUMMARY AND RECOMMENDATIONS

7.1 INTRODUCTION

The foundational framework for conducting an investigation of this nature was rooted in the curriculum revisions which occurred in the education sector of South Africa. Both the 2000 and 2009 Review Committees identified inadequate teacher training and the quality of learning materials used in the classrooms. This study positioned itself to use these inadequacies to launch an investigation into how affect could influence the learning of Mathematics and in so doing allow teacher-training not only to be the focus of cognition but also expose student teachers to the influences of affect on the learning processes. At the same time, an investigation into the concerns of Mathematics student teachers was undertaken by introducing social context learning packages to be used in addition to classroom learning materials. The learning packages provided student teachers and learners with exposure to the mathematising of real-time topical issues and newsworthy events. This chapter addressed the research questions formulated on the basis of the problem statement in paragraph 1.2. Based on the findings of the investigation, recommendations are made for both institutional level and field level.

7.2 ADDRESSING THE RESEARCH QUESTIONS

The objectives of this study (see paragraph 1.3) were addressed by the following research questions:

7.2.1 Research Question 1

Question: How do *affect constructs* influence student teachers' learning of Mathematics?

Objective: Describe how affect constructs such as attitudes, beliefs, emotions and values impact on student teachers' learning of mathematics with special regard to promoting the development of mathematical competencies.

In answering *Research Question 1*, evidentiary (qualitative) data from this study supported the contention as there were distinct patterns in the overall expressions of participants about the influence of affect on the learning of Mathematics (see paragraph 6.4). These results could be triangulated with the views of McLeod (1992:575) who states that affective issues play a central role in Mathematics. A positive polarity of each of the (affect) variables could be interpreted as a positive orientation towards the learning of Mathematics and *vice versa*. For instance, most of the respondents agreed to the sentiment that a positive *attitude towards mathematics* can lead to the enjoyment of and less frustration in learning and doing Mathematics and possibly leading to an increased level of confidence about doing well in Mathematics (see Appendix J: items 9 & 10; also see paragraph 6.2.1.1). At field practicum level, the impact that some of the student teachers wanted to have on their learners was for them (learners) to develop a positive attitude toward the learning of Mathematics by changing their mindset and perceptions of Mathematics (see Appendix J: item 4).

Concerning the affect variable *beliefs about mathematics*, this study showed that a positive belief in one's own ability could lead to one's doing well in Mathematics (see Appendix J: item 10, also see paragraphs 6.2.1.2 & 6.4). Furthermore, 81% of respondents expressed a positive *emotion* (enjoyment) when asked to score the item: *When busy with mathematical assignments or tasks* (see Table 6.1; Appendix J: item 23; also see paragraphs 6.2.1.3 & 6.4). In addressing the link between personal *values* and achievement, 94% of the respondents acknowledged that such a link does exist, citing that a person with good values has good attitudes and work ethics that could lead to a high level of achievement (see paragraph 6.2.1.4) and for some respondents, good values could be a source of motivation to do well in Mathematics (see paragraph 6.4).

McLeod (1992:575) states that “if learners are going to become *competent* learners of Mathematics, their affective responses to Mathematics are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low order mathematical skills”. In addition, Snyders (2008:235) posits that “to be successful in any field of study in the broad area of Mathematics, a number of skills and competencies need to be developed”. Liljedahl (2005:219) states that “the affective domain has had a positive influence on resistant students’ mathematical competencies”. (See paragraphs 2.5 & 2.6 for an explication on affect and mathematical competencies.) In sum, positive experiences and stability are essential in the affective domain because of the influences they can exert on the learning of Mathematics, which can invariably determine how competent a learner can view himself/herself in Mathematics. Learners (and students) with strong self-concept, high confidence and positive motivation have the potential of becoming highly competent Mathematics learners.

7.2.2 Research Question 2

Question: What are the *concerns* of Mathematics student teachers during the field practicum sessions?

Objective: Explain the use of the Fuller-Brown model of teacher development to determine what the concerns of Mathematics student teachers were during field practicum (whether it was concerns about survival, task or impact) and whether there was any translation within a developmental hierarchy of concerns. An experiment sample (from the NIHE site) and control sample [from the NWU (Potchefstroom campus)] were used in a pre-post quantitative measurement format.

Factor analysis revealed the emergence of FOUR factors (sub-scales) as opposed to the three sub-scales (Self, Task and Impact) used in the Fuller-Brown model (see paragraph 6.3.2). The three sub-scales of the Fuller-Brown model were modified on the basis of factor analysis to a two-factor model for further use in the data analyses (see paragraph 6.3.3 & Table 6.4).

This statistical result was further supported by the narrative data (see Appendix J: item 22) which revealed a close homogeneity in responses for task and impact criteria when respondents had to describe when their emotions were most intense. In addition, when responding to the question on values (Appendix J: item 39), the participating student teachers were less focused on the values they had that dealt with their survival in a mathematics classroom, and more focused on the values that dealt with the mathematical tasks they had to perform and with the impact they had on their Mathematics learners.

Since the Fuller-Brown model proposed a developmental hierarchy of concerns, the detection of such a translation was no longer an objective to pursue in the two-factor model. As a consequence the Fuller-Brown model was no longer the operational model in this study as were its three sub-scales. Nevertheless, Figure 6.2 and Figure 6.3 show translations in a session (per factor and per group) and translations between sessions (per factor and per group). The two factors were identified as concerns about self-benefit and concerns about learner-benefit. In answering *Research Question 2*, it could be inferred statistically that Mathematics student teachers from both groups were moderately concerned with all the sentiments expressed in the concerns statements in each of the items on the SCQ (with the exception of items 2 and 10). No classical trends as noted in the concerns theory could be detected in this study. This could be ascribed to the fact that the SCQ was modified to reflect aspects of mathematics teaching and learning, as well as being completed by only Mathematics student teachers and not by the general student population as was done in other research studies. Also, the SCQ used in other studies was fundamentally generic in basis and did not reflect any subject orientation. No generalisation of these (statistical) results was intended as the study was designed for the study population described in paragraph 5.2.2.

7.2.3 Research Question 3

Question: To what extent does the use of and interaction with social context learning packages during field practicum sessions (in the intervention strategy) play a role in addressing the concerns of Mathematics student teachers at the NIHE?

Objective: Describe how the use of social context learning packages (in the intervention strategy) impacted on changing the concerns (if any) of the experimental sample of Mathematics student teachers, when engaging in:

- making decisions (biased/unbiased) on topical issues and newsworthy events;
- constructively dealing with the Mathematics of the learning packages; and
- examining thoughtful decision-making on social context issues.

In answering *Research Question 3*, the use of learning packages in the intervention strategy had minimal or insignificant influence on improving or mitigating the concerns of the Mathematics student teachers from the experimental sample. Rather, there was a decline in confidence in the participants' abilities to design their own learning packages and in whether their learning packages were appropriate for use by their learners. These contentions were supported by the statistical results in Figure 6.2 and Figure 6.3. The difficulties alluded by student teachers in designing their own learning packages could be partly ascribed to the problematic selection of topical issues and newsworthy events that could possibly reveal the designers' biased or non-biased orientations (see paragraph 4.2.1.2). The Mathematics of learning packages and the thoughtful decision-making on social context issues had been addressed through the formulation of the socio-mathematical questions in the learning packages (see paragraph 4.2). The interviewing process (see paragraph 6.2.2) revealed that Mathematics student teachers' responses were convergent in indicating a preference for using learning packages in mathematics classrooms throughout South Africa. In the written responses towards the use of the learning packages (see Appendix J), the difficulties noted in the implementation of these learning packages were that they were time consuming, that the context (global) was sometimes unfamiliar to the learners and that the content of the learning packages was not always linked (theme-wise) to the lesson topic that had to be taught. In addition, the emotions experienced by some participants when using the learning packages ranged from being overwhelmed and apprehensive to some form of excitement as to the prospect of using them in their mathematics lessons. Once more, the perception of time spent on using learning packages came to the fore: "I was stressed as I knew that using the learning packages in my lesson would be time-consuming as my lesson period was only 30 minutes."

The practice of mathematising topical issues and newsworthy events during the second session of field practicum (for Group 1) elicited an overwhelming number of negative emotions from the participants (see paragraph 4.2.1.2).

Emotions of feeling extremely challenged, anxious and frustrated were indicative of the range of difficulties experienced by the participating student teachers when embarking on a task about which they may have been uncertain or uncomfortable. When engaging in the use of learning packages, the values some respondents wished to impart to their learners were an awareness of what was happening in the world, to be critical and not be neutral to social, political, economic, etc. upheavals in the world, to be able to accommodate other people's views on events, to develop a level of empathy and sympathy with people caught up in situations and to show respect and understanding to other citizens of the world by promoting good social values (see Appendix J: item 40).

7.2.4 Research Question 4

Question: Within the theoretical premises and the empirical results of this study, how can the Mathematics student teachers' perceived affect and concerns be addressed at institutional level and at field practicum level respectively?

Objective: Propose a mathematics programme as part of the teacher-training programme at institutional level that incorporated not only cognition but also affect in the learning programmes for Mathematics. Similarly, at field practicum level, a lesson programme (incorporating the use of learning packages) will be proposed to track changes in concerns of Mathematics student teachers during field practicum sessions.

The findings of the results in paragraphs 6.4.1, 6.4.2, and 6.4.3 were collated to address *Research Question 4* (see paragraph 7.3). The level of teacher education effectiveness can be informed by its programme offerings.

The recommendations made for programme offerings included a mathematics programme and a lesson programme (discussed in paragraphs 7.3.1 & 7.3.2 respectively) that might help to stimulate discussions about conceptual variations among teacher education models. These teacher education models must be willing to incorporate current trends and contemporary approaches in mathematics education into functional and structurally-aligned mathematics teacher-training models.

7.3 RECOMMENDATIONS

In a naturalistic setting, life in a mathematics classroom may be viewed as a form of social interaction by considering the normative aspects of classroom interaction that are specific to Mathematics. In preparing Mathematics student teachers to meet the demands of the classrooms, one has to acknowledge that there is no single best format for teacher education programmes, as they can vary in structural and conceptual formats. With the preceding statement in mind and in addressing *Research Question 4* the following recommendations, based on the results and findings of the investigation, are made in paragraphs 7.3.1 and 7.3.2.

7.3.1 Institutional Recommendations

The proposed mathematics programme for use at institutional levels differs considerably from the traditional programmes on offer at most HEIs, in that the focus is not only on increasing knowledge in the field of Mathematics but by allowing student teachers to be exposed to research and become action researchers by investigating not only cognitive demands and achievements in Mathematics but also consider other factors that could influence the teaching and learning of Mathematics. Schiefele and Csikszentmihalyi (1995: 164) state “that the impact of affective constructs is often underestimated because they tend to have indirect rather than direct effects on achievement”. To obtain optimal performance in the teaching and learning of Mathematics, researchers in mathematics education need to acknowledge the role and impact of affective issues and integrate it into studies of cognition.

This view is supported by McLeod (1994:642) who recommends a more integrated approach to research on affect and cognition. Another non-cognitive factor that became a focus of this study was the concerns student teachers had during the field practicum sessions. An important study undertaken by Goh and Matthews (2011:92-103) on the concerns of student teachers during field practicum, identified concerns about classroom management and student discipline, institutional and personal adjustment, classroom teaching and learner learning. HEIs are important in bringing rigour and status to teacher education. With this in mind, a mathematics programme is proposed that could address the perceived affects of student teachers toward the learning of Mathematics. Students with positive orientations towards affect constructs have the potential of becoming highly competent Mathematics students.

Recommendation: Measurements of student teachers' affect, at institutional level, can be done using an ABEV questionnaire (similar to the one used in this study). The time frames for the measurements can take on a pre-post format during a term, semester or an academic year (see the temporal spectrum in Figure 7.1). By re-orientating the mathematics curriculum, a mathematics programme is proposed that takes cognisance of the results of the first measurement and incorporates them into the pedagogy of the mathematics curriculum. In doing so, the mathematics programme takes on a mixed-mode epistemological design of cognition and affect. The results of the second measurement can serve to monitor student/learner performance and achievements or to effect changes to the measuring instrument for further use.

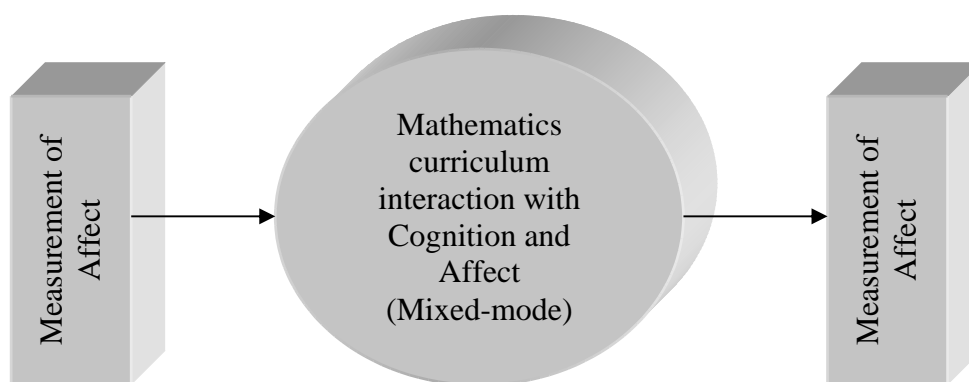


Figure 7.1: A Mathematics Programme incorporating aspects of Cognition and Affect

The potential outcomes of such a mixed-mode mathematics programme could lead to teacher improvement, student improvement and better curricular understanding. Since teacher improvement can be linked to the professional development of teachers who seek professional growth to become more effective as teachers, by exposing prospective teachers to a mixed-mode mathematics programme could one day become beneficial to them as they seek ways to improve their own abilities as Mathematics teachers. Student improvement can be linked to their mathematical abilities and competencies (both cognitive and affective), and student teachers' perceptions about Mathematics can be used to improve their attitude, beliefs, emotions and values towards and about Mathematics. Numerous curricula revisions (especially in South Africa) have as their focus the need to develop an interpretive and implemental curriculum. Curricular understanding is essential for new, additional or alternative knowledge delivery methods. Based on the schema in Figure 7.1, the following sub-recommendations are made for consideration at institutional level:

- Longitudinal studies be undertaken to measure any variances (developments or changes) in affect at institutional level.
- More research must be done on the ABEV questionnaire for use at HEIs as well as at school level.
- Mathematics curricula revisions should pay more attention to the influences of the affect on the teaching and learning functions. The revisions should be informed by the empirical results of the measurements of affect.

7.3.2 Field Recommendations

This investigation was intended to focus attention to the underlying reasons given by student teachers about their concerns before and during the practicum in order to integrate areas of concern into future management and development of teacher education. According to Goh and Matthews (2011:92), the value of their study was in the pursuit of using student teachers' own capacity to self-assess and appraise their circumstances as a research area in teaching. It was also useful to know how the understanding of learning to teach could be enriched through self-awareness of the circumstances surrounding them as student teachers.

The research focus of Goh and Matthews was synonymous to this study, in that both studies seek to acknowledge the influence of student teacher concerns on the teaching processes during field training. Teacher-training programmes rely greatly on schools to provide sites for field experiences. A great number of concerns have been noted by student teachers as they encounter the realities of the classroom. The practicalities of the classroom may not be coherent with what the (education) theories predict. In order to maintain some form of synergy and coherence between theory and practice, student teachers must be given the opportunity to negotiate their concerns through reflection and practice. The process of measuring these concerns can inform the field practicum programme of what needs to be done in order to address or ameliorate the concerns of student teachers when they are out for field training.

The concerns of student teachers need to be addressed to ensure that cohorts of competent and highly qualified teachers exit their training well-prepared and confident to tackle the demands of the teaching profession. The need to address the concerns can be viewed coherently with the need to have an effective lesson programme that is much more subject-specific and not just a generic design for use during field practicum. The demands of lesson planning have been noted by Reed (1995:58) as a task-concerned item, as well as during an interview conducted by the researcher, who noted the concern about coping with mathematics lesson planning (see paragraph 3.7).

Recommendation: The following lesson programme for use during field practicum is proposed that includes aspects of both traditional and contemporary pedagogy. Landscaping the lesson design (see Table 7.1) entails starting off with the traditional pedagogy of set establishment (*Introduction Phase*). This could be achieved through drill work and the use of mental arithmetic and is based on the call for *back to basics* aimed at improving learner performance (see paragraph 1.2), as well as an attempt to improve basic numeracy (see DBE, 2011a). The traditional pedagogical approach is carried into the *Presentation Phase* with the teaching of conceptual and algorithmic knowledge. The notion here is to adequately prepare Mathematics student teachers to possess content knowledge needed for teaching, thus equipping them with good quality initial training. A switch is made to a learner-centred and activity-based mode of teaching (with a socio-constructivist undertone) when dealing with the social context learning packages in the presentation phase.

Table 7.1: An Exemplary Programme for a Mathematics Lesson

CORE CONTENT	LESSON PHASE ATTRIBUTES
<p><u>Introduction Phase</u> Mention only the <i>core content</i> (in this column) that will be dealt with in this phase.</p> <p>Do not write (in this column) what the teacher/learner will be doing, rather give the subject matter that will be dealt with during this phase</p>	<p><u>SET ESTABLISHMENT / SET INDUCTION</u></p> <p><u>Step 1: Drill work</u> [As part of a set induction process towards foundational numeracy]</p> <ul style="list-style-type: none"> ■ Learners recite multiplication tables appropriate to grade. [E.g. Grade 7 =13 times table or Grade 10 = 17 times table] ■ Teacher directs this activity. <p><u>Step 2: Focus on foundational aspects of numeracy</u></p> <ul style="list-style-type: none"> ■ Learners must read out a mathematics riddle/puzzle that they must solve mentally and explain verbally how they got the answer OR any other suitable foundational numeracy activity. ■ Teacher directs this activity. <p><u>Step 3: Link with prior knowledge or pre-knowledge</u></p> <ul style="list-style-type: none"> ■ Brief revision by the teacher of previous lesson or pre-knowledge that will link with the lesson experience (lesson topic) from a Learning Outcome (LO) and its associated Assessment Standards (AS). ■ Learner activity under teacher’s guidance. Teacher provides remedial assistance if required. <p><u>Step 4: Link with the lesson focus of the Presentation Phase</u></p> <ul style="list-style-type: none"> ■ Activity that will link with the theme(s) in the presentation phase. ■ Teacher direct-guide-monitor activity.
<p><u>Presentation Phase</u> Mention only the <i>core content</i> (in this column) that will be dealt with in this phase.</p> <p>Do not write (in this column) what the teacher/learner will be doing, rather give the subject matter that will be dealt with during this phase</p>	<p><u>Step1: Teaching of Conceptual and Procedural Mathematical Knowledge</u></p> <ul style="list-style-type: none"> ■ Focus on teaching concept/procedure using Activities/Examples /Exercises. ■ Learners must observe what is being taught. Focus on concept development and/or concept consolidation. ■ Teacher must drill the algorithm(s) as per mathematical task or problem that is being taught during this step. ■ Teacher must facilitate learning/guide/assist/mentor learners. Teacher MUST intervene if the need arises by explaining what must be done or how it must be done. <p><u>Step 2: Learning Package: Social Context Problem</u></p> <ul style="list-style-type: none"> ■ Teacher presents topical issues or newsworthy event that must be dealt with. ■ Learners must first try to solve it first on their own/groups - must construct their own problem-solving methods. However, learners are encouraged to work on these learning packages outside the formal classroom settings at their own pace. ■ Report back: Teachers MUST direct or guide discussions on possible mathematical solutions as well as open debate on the social issues raised in these learning packages. ■ Note: One topical issue is addressed per week that is captured by two Learning packages: <i>At the beginning of the Week</i> learning package and <i>At the end of the week</i> learning package. Teacher must ensure the utilisation of these learning packages to be synchronised to the unfolding of topical, newsworthy issues within a period of real-time chronology.
<p><u>Concluding Phase</u> Mention only the <i>core content</i> (in this column) that will be dealt with in this phase.</p>	<ul style="list-style-type: none"> ■ Consolidate newly acquired knowledge by Fun Activities, Relay Race, etc. ■ Homework may be given – can start completing it in the class or as a take-home activity.

As noted in paragraph 4.3, the rationale for introducing the learning packages at school level, in addition to LSMs, is to provide an alternative orientation in dealing with real-world issues and events in the classroom. In the *Concluding Phase* a learner-centred and activity-based mode of teaching is maintained. The proposed lesson programme design is generic in nature and can be used for the purpose of further development, adaptations or modifications.

The following sub-recommendations are made with regard to the measurement of student teacher concerns during field practicum:

- Measurements should be taken before and after the two field practicum sessions to detect any developments in student teachers' concerns.
- Further adapt and modify the SCQ for use in other subjects or at school-level.
- Use the results of the measurements to effect changes to the field practicum programme, as well as establishing a negotiating forum between school and institution to address the issues that are of most concern to the student teachers.

7.3.3 Recommendation for a Web-based Learning Repository

The importance of e-Learning has become a major focus of education institutions and the notion of sharing has allowed teachers to find available resources online. According to Lee (2001:121), unlike learning in traditional classrooms, web-based learning (or e-Learning) presents a new environment which can either be accepted or rejected depending on the adaptation of the learning process. This study recommends a web-based learning repository that will allow teachers, students, learners or any interested person to access or contribute to the use or development of learning packages for Mathematics. The benefits of using learning packages need to be made clear to teachers and teachers need to incorporate these packages in the teaching process in such a way that learners use them in a systematic manner for learning, revising and practising. Positioning learning packages within web technology could possibly influence the way learners learn, especially promoting responsive feedback, individual involvement and co-operation through collaborative learning. Several factors have limited the possibility of generalising the results. These limitations are discussed in paragraph 7.4.

7.4 LIMITATIONS OF THE STUDY

Study limitations need to be noted so that researchers can provide additional evidence to inform practice decisions if further research is to be undertaken or a replicability of the study is done. It is also important to present the findings of this study in relation to the study limitations. The following limitations for the study are presented in the following sub-paragraphs.

7.4.1 Conflict of Interest and Bias

This limitation stems from the direct association which the researcher had with the research settings and the participating Mathematics student teachers. It is possible, therefore, that at least some of the respondents might have been somewhat ambivalent about completing the ABEV and SCQ questionnaires and participating in the interviews, notwithstanding the assurance given to them with respect to anonymity and confidentiality. It is indeed possible that some of the respondents might have felt uncomfortable and uneasy about expressing any views which might reflect on their teacher-training programme. Students seemed to be very careful about compromising their relationship with those persons who are responsible for assessing their performances and achievements.

7.4.2 Study Population and Sample

The study population consisted of sample groups from the NIHE and from the NWU (Potchefstroom campus). Even though the sample size for the experimental group (Group 1) remained constant during all the measurements, sample size variation was noted for the control group (Group 2) that showed a decline during the two sessions of measurement (during field practicum). Since participation in this study was voluntary (as noted during the researcher's address to the student teachers at both the NIHE site and the Potchefstroom campus in 2011), the number of respondents from Group 2 during session 1 was 49 and during session 2 the number was 24. Even though the sample sizes were small, the significance of the data sets (both qualitative and quantitative) was worth analysing.

The reality of the situation, however, was that a substantial part of the study was undertaken primarily at the NIHE within the Northern Cape Province. Although the largest province in South Africa it is still very rural and sparsely populated there is still a distinct disparity in student population numbers at the NIHE compared to well-established universities in other provinces.

7.4.3 Instrumentation

Qualitative limitations were confined to the ABEV questionnaires and the interviews. It was evident that some respondents experienced difficulty in comprehending and interpreting the written questions/statements on the ABEV questionnaire. This could perhaps be ascribed to the fact that English may for some be their second or even third language. With regard to the interviews, inaudible responses posed a challenge in the transcription process. Some of the respondents were unsure what to answer and provided answers not relevant to the questions posed.

In most cases the researcher had to rephrase the question or had to limit their responses within the parameters of relevancy. The researcher acknowledges that some of the questions could have been construed by the participants as being intimidating and took all precautions to set the respondents at ease. The researcher was also very wary to prevent the *Hawthorne Effect* from emerging during the interviewing sessions.

With regard to the quantitative limitations in this study, the SQC was modified and adapted from the one used by Reed (1995:266) to reflect a more mathematical-oriented investigation. The results of factor analysis of the SCQ showed the emergence of FOUR factors (sub-scales) as opposed to the three sub-scales (Self, Task and Impact) used in the Fuller-Brown model. Only the first two factors were meaningful to be retained. The other two factors were discarded on the basis of having an insignificant value or having a low Cronbach's alpha coefficient. Hence, the Fuller and Brown model of teacher development, which represented a three-stage model that indicated a developmental sequence of concerns from self concerns → task concerns → impact concerns, was relegated in this study, based on empirical evidence, in favour of the two-teaching phases approach of Fuller (1969).

7.4.4 Design Errors

The researcher recognises certain limitations inherent in the research design. Since this is not a dedicated longitudinal study but rather a "snapshot in time," over two field practicum sessions, it is not possible to state unequivocally a cause and effect relationship between involvement in the study and student success. This study may also be difficult to generalise to other types of programme offerings with different settings, requirements and qualifications.

7.4.5 Trustworthiness of Coding the Data

The researcher acted as the single coder for the data collected that might not be in defence of greater trustworthiness in coding data since multiple coders are usually used to obtain higher inter- and intra-coding reliability.

7.4.6 Limited Related Research undertaken in South Africa

The absence (or minimal number) of related research studies in South Africa focusing on the influence of affect on the learning of Mathematics and the concerns that Mathematics student teachers have during field practicum meant that this study had to rely on related overseas research. The latest curricula revision (of previous curricula) had posed some problems to the period in which this research was undertaken and the necessary structural changes had to be reflected in this study.

Notwithstanding the limitations inherent to this study, the researcher has reason to believe that the varying number of the responses, both qualitative and quantitative, was significant enough to be representative of a cross-section of the Mathematics student teachers at both the NIHE site and the NWU (Potchefstroom-campus). Furthermore, the consistency and pervasiveness of the data sets in the empirical study give reasons to believe that the findings can be generalised to those who had participated in this study.

7.5 CLOSING PERSPECTIVE

Soobryan (2010:21) states that teacher development is the area requiring perhaps the greatest degree of innovation. By noting the inadequacies reported by the 2000 and 2009 Review Committees, this study positioned itself to address these inadequacies at institutional and field levels. The findings of this study, together with relevant literature support, showed that the teaching and learning of Mathematics could serve as mediators to both cognitive and affective characteristics. By acknowledging this notion of an integrated cognitive-affect approach to teacher education it will cover a significant distance in understanding the complexity of human behaviour. This behaviour is not just explained by the actions of students in terms of general cognitive rules based on the cause-effect approach but also taking into account the consideration of affect on human behaviour. In addition, by acknowledging too the concerns that student teachers have during field practicum, it could possibly empower them with unique coping skills needed when they enter the teaching profession as newly qualified teachers.

The need to prepare and train effective Mathematics teachers and raise the academic calibre of Mathematics student teachers were fundamental to the overall design of this study. It is hoped that curriculum planners and designers will consider the recommendations of this study to address the so-called inadequacies in the education system of South Africa noted and reported on in this study. School-based curricula should be seen as a vehicle to effect changes and provide some form of cohesion with the dynamics of teaching and learning. The ultimate aim of having a dynamic, interactive and flexible curriculum model is to bring about effective teaching and meaningful learning. Subject-oriented programmes must deal more adequately with the realities of the classroom. These matters are important, especially when keeping in mind the aims and intended learning experiences when prospective teachers undergo institute and field training as they prepare themselves for their profession.

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9. Explain why you think an *attitude towards mathematics* can be closely linked to the level of commitment towards Mathematics.
10. Explain why you think a positive *attitude towards mathematics* can contribute in improving one's own mathematical ability.
11. What change in attitude do you think teachers experienced when changing from an old Mathematics curriculum to a new one?
12. What do you think happens to a learner that experiences repeated negative emotions towards Mathematics?
13. The common belief that low achievement in Mathematics can be blamed on low socio-economic status, unwillingness to learn or personal disabilities. Explain why you agree or disagree with this statement.
14. Why do you think many people believe that only geniuses can be creative in Mathematics?
15. Many students and learners believe that Mathematics usually involves mainly memorization and following rules. Do you think this statement is true? Give a reason for your answer.
16. Did your experiences with Mathematics help shape your beliefs about mathematics?
17. Explain why you think some teachers believe that they have a strong influence on the beliefs of their learners.
18. Do you agree that many teachers' beliefs and views seem to be shaped by their experiences in the classroom?

19. Do you as a prospective mathematics teacher believe that you have received adequate training around the learner-centred and activity-based curriculum (NCS and/or CAPS)?
20. Explain why you would agree/disagree with the view that by understanding learners' *emotions towards mathematics* can help you better understand their (learners') *beliefs about mathematics*.
21. Describe the emotions you experience when doing Mathematics.
22. State when your emotions are most intense:
- (a) When thinking about your own abilities when doing Mathematics.
 - (b) When helping learners with mathematical problems or tasks.
 - (c) When you worry whether learners have learnt what you taught them.

Complete the following table by making a cross (X) next to your selection.

Statement	Emotion Construct	
	Description of the emotion	Place (X) in this column
23. When busy with mathematical assignments or tasks.	Enjoyment	
	Boredom	
24. When waiting to write a Mathematics classtest.	Anxiety	
	Hope	
25. When receiving the results of a Mathematics test.	Relief	
	Sadness	
26. When a mathematics award is made to your fellow student, how do you feel knowing that you have also worked as hard or even harder than that student in Mathematics.	Contempt	
	Admiration	

27. When learning Mathematics, do you experience just one type of emotion or a number of varied emotions as the learning progresses? Provide an explanation to your answer.

28. When encountering the social context nature of the learning packages, what is your emotional reaction towards the use of the learning packages in a mathematical activity?

29. Describe the emotions you have experienced when mathematising topical issues or newsworthy events for use in learning packages during the second session of teaching practice.

30. Say why you agree/disagree with the fact that the values of a person can determine their level of achievement or performance as well aid in their self-evaluating.

31. *Values about self* entail identifying what values students think they have in order to be successful in mathematics. Write down TWO such values.

32. *Values about task* entail the notion of what values students possesses in completing a mathematical task successfully. Write down TWO such values.

33. Give the difference between *beliefs about mathematics* and *values about mathematics as you understand it*.

Complete the following table by providing an appropriate example to illustrate the meaning of the predictor

Values constructs in relation to the learning of mathematics		
Variable	Predictor	Mathematics Example
Values about self	Integrity	34.
	Sensitivity	35.
Values about task	Perseverance	36.
	Satisfaction	37.

38. State the reason why you are willing (or not) to attach values to Mathematics as a life priority.

39. Are the values you have as a Mathematics student teacher more focused on your own survival in a mathematics classroom or on the mathematical tasks you have to perform or on what impact you may have on your Mathematics learners?

40. By considering the social context nature of the learning packages, what are the types of values that you wish to impart to your learners?

Thank you for your kind cooperation

APPENDIX B

INTERVIEW GUIDE

CODE: Session Time

SAMPLE:

SEMI-STRUCTURED INTERVIEW CONDUCTED WITH THE EXPERIMENTAL GROUP (GROUP 1)

Reflect on the following statements and question:

Statement 1: *Comment on your understanding and interpretation of traditional word problems, contextualized problems and social context problems.*

Question 1: *Was the use of learning packages during the field practicum sessions of concern to you?*

Statement 2: *Comment on the suitability of using social context learning packages in South African mathematics classrooms.*

[Note: The construction of this interview guide allowed the researcher to use probes with the view of clearing-up vague or ambiguous responses or to ask for elaboration of incompleted answers. The interviewee was also given the opportunity to raise other issues (subsidiary questions) not addressed by the researcher.]

APPENDIX C

CODE: Session

1

 Time

Pr

NIHE-SCQ

1/Pr/NIHE

STUDENT CONCERNS QUESTIONNAIRE (SCQ)

Adapted from TCQ (George, 1978)

Kindly complete this questionnaire. Your responses will be **strictly confidential**.

The purpose of this questionnaire is to establish what Mathematics student teachers are concerned about at different stages of their teaching experience during teaching practicums. In order to maximize the benefits of the teaching practicum for student teachers, one needs to address the concerns of students related to their teaching practice experiences.

Definition of concern: A person is *concerned* about something if it is of interest, importance or if he/she is anxious about it.

For each of the statements below, please indicate the extent of your *concern* by placing a cross (X) in the appropriate column AND writing down the number chosen in the empty cell provided. There is no correct or incorrect answer to any of the statements. Please use a blue or black pen when scoring. Example of how to score:

How much are you concerned about:

Meeting the needs to become an effective mathematics educator (teacher)	1	2	X	4	3
---	---	---	----------	---	----------

The scoring implies that the student teacher is *moderately concerned* about meeting the needs to become an effective mathematics educator.

CONCERNS SCALE

1= not concerned at all
2= very little concerned
3= moderately concerned
4= extremely concerned

How much are you concerned about:

1. Meeting the needs of different kinds of mathematics learners	1	2	3	4	
2. Working with too many mathematics learners each day	1	2	3	4	
3. Doing well when being observed as you teach a mathematics lesson	1	2	3	4	
4. Being able to achieve the outcomes/goals of a mathematics lesson	1	2	3	4	
5. Challenging unmotivated learners when teaching mathematics	1	2	3	4	
6. Your ability to plan and prepare adequate mathematics lessons	1	2	3	4	
7. Teaching an outcomes-based mathematics lesson	1	2	3	4	
8. Diagnosing learners' mathematics problems during teaching practice	1	2	3	4	
9. Being accepted and respected by other professional educators	1	2	3	4	
10. Having too many non-teaching duties, for example photocopying, sports, etc.	1	2	3	4	
11. Whether each learner is reaching his or her mathematics potential	1	2	3	4	
12. Losing the respect of your learners with regard to your teaching abilities	1	2	3	4	
13. Learners lacking the ability and skills to solve mathematical problems	1	2	3	4	
14. Being able to guide learners to construct their own solutions	1	2	3	4	
15. Maintaining class control and discipline	1	2	3	4	

Thank you for your kind cooperation

Information relating to the SCQ

The SCQ is the quantitative research instrument and is a 15-item Likert-type questionnaire to assess and examine the concerns of pre-service mathematics students during field practicum sessions. This questionnaire will be administered to both the experimental sample (Group 1= Mathematics student teachers from the NIHE) and the control sample (Group 2= Mathematics student teachers from the NWU) in a pre-test and post-test format during each of the two teaching practice sessions of 2011.

Features of the Concerns' Questionnaire:

- Fuller's concerns categories of *concerns about self*, *concerns about task* and *concerns about impact* are used in this study, however the student concerns items in the categories are modified as done by Reed (1995);
- The construction of the questionnaire items for the *SCQ* is informed by studies of other researchers, *inter alia*, Christou, Eliophotou & Philippou (2004) and Ponte & Chapman (2008);
- The *SCQ* is used during field practicum sessions and is coded according to an *a priori* set of codes, that is, codes developed before examining the data; and
- Measurements are taken before and after the two teaching practice sessions to detect any developments in the concerns of students as expounded upon by Fuller (1969).

Features of the Coding used on the SCQ:

I have scrambled the items on the questionnaire to prevent students from identifying which items fall within the concerns categories of *self*, *task* and *impact*. Refer to table below for item categorisation:

Concerns categories	Items				
SELF CONCERNS	3	6	9	12	15
TASK CONCERNS	2	4	7	10	13
IMPACT CONCERNS	1	5	8	11	14

Coding the questionnaire

Session 1 = First Practice teaching session

Time **Pr** = Pre-test

Code: 1/Pr/NIHE & 1/Pr/NWU

Session 1 = First Practice teaching session

Time **Po** = Post-test

Code: 1/Po/NIHE & 1/Po/NWU

Session 2 = Second Practice teaching session

Time **Pr** = Pre-test

Code: 2/Pr/NIHE & 2/Pr/NWU

Session 2 = Second Practice teaching session

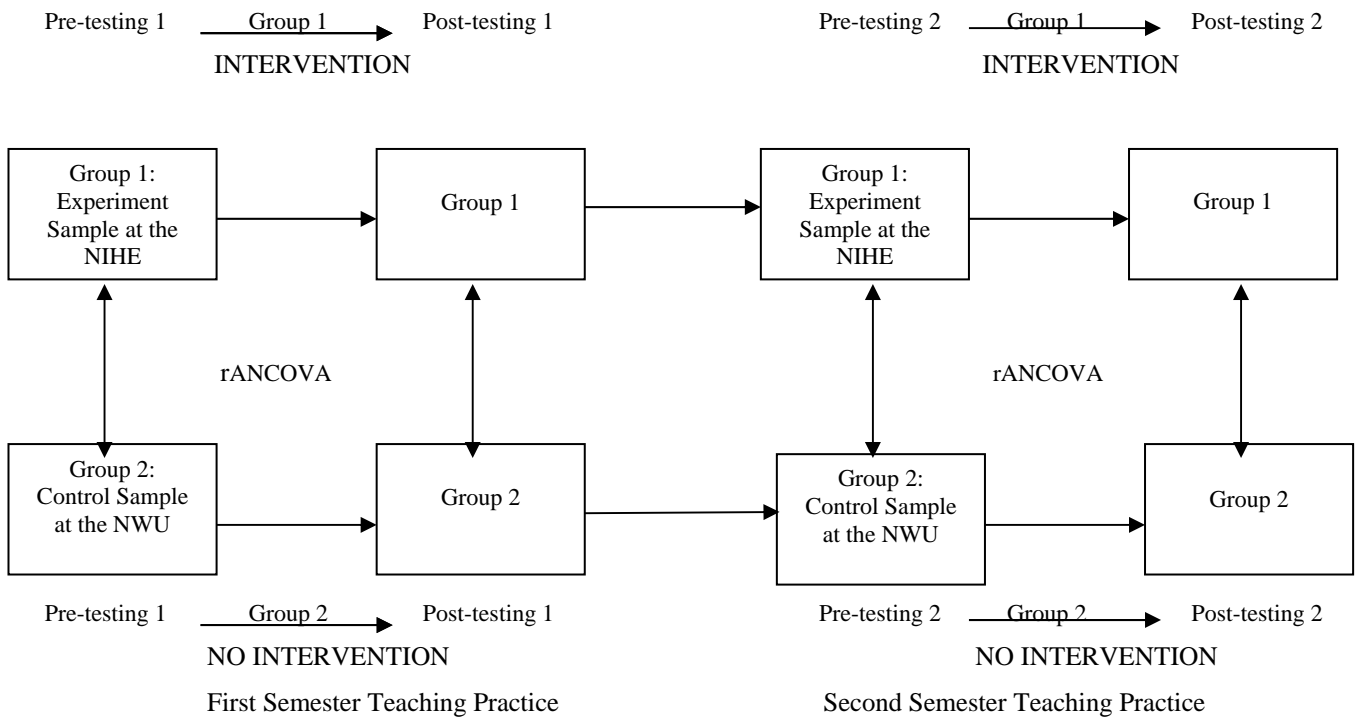
Time **Po** = Post-test

Code: 2/Po/NIHE & 2/Po/NWU

NIHE-SCQ = Administered to students at the NIHE (Experimental group)

NWU-SCQ = Administered to students at the NWU (Control group)

The schema below indicates the manner in which the quantitative measurements for the study variable *concerns* are done within a temporal range.



APPENDIX D

LETTER TO THE FACULTY OF EDUCATION CO-ORDINATOR

24 January 2011

**The Faculty Head
Faculty of Education
National Institute for Higher Education (NIHE)
Northern Cape
Galeshewe Campus
Kimberley**

Dr A. Du Plessis

I am currently enrolled for the PhD degree in the field of Mathematics Education at the North-West University (Potchefstroom Campus). I hereby wish to apply for permission to conduct an investigative study at the Galeshewe campus during the 2011 academic year using a sample of mathematics student teachers (purposely selected) from the NIHE site to facilitate the collection of statistical/non-statistical data to aid the quantitative/qualitative analyses of the study respectively. Permission has already been sought from the North-West University and the District Manager of the Frances Baard District, Northern Cape Education Department to conduct part of the empirical study during the first semester teaching practice session of this year.

I sincerely hope that this request would be considered in a favourable manner. The aim of the study is to investigate affect and concerns of mathematics student teachers with special reference to social context learning packages. The primary outcome of this research is the proposal of a mathematics programme at institutional level that will incorporate the qualitative measurement of affect in the learning of mathematics. At field level, a lesson programme (incorporating the use of learning packages) will be proposed for mathematics students in order to track and possibly remediate changes in concerns during teaching practice.

Kind regards.

Nazir Hassan (Student Number:xxxxxxxx)

nhassan@xxxxxx.co.za

cell number: xxxxxxxxxxx

APPENDIX E

LETTER TO THE DISTRICT MANAGER



24 January 2011

**The District Manager
Frances Baard District
Hayston Street
Hadison Park
Northern Cape Education Department
Kimberley**

Madam

I am currently enrolled for the PhD degree in the field of Mathematics Education at the North-West University (Potchefstroom Campus). I am seconded to the National Institute for Higher Education [NIHE (Northern Cape)] from the Northern Cape Education Department. I wish to apply for permission to visit the schools during the teaching practice sessions so as to allow me to conduct an investigative study using the mathematics student teachers to facilitate the collection of statistical/non-statistical data to aid the quantitative/qualitative analyses of the study respectively. These students will be placed at schools during the first and second semester teaching practice session for three weeks in April 2011 and three weeks in July 2011. This will be the only opportunity that I will have to collect the data required for my study.

I sincerely hope that this request would be considered in a favourable manner.

Kind regards.

Nazir Hassan (Student Number: XXXXXXXXXX)

nhassan@XXXXXX.co.za

Cell number: XXXXXXXXXX

APPENDIX F

LETTER TO THE DEAN: FACULTY OF EDUCATION (NORTH-WEST UNIVERSITY)



19 January 2011

The Dean
Faculty of Educational Sciences
North West University
Potchefstroom Campus
Potchefstroom

Prof B. Richter

I am currently enrolled for the PhD degree in the field of Mathematics Education at the North-West University (Potchefstroom Campus) with Professor Hercules Nieuwoudt being my primary supervisor. I am currently seconded to the National Institute for Higher Education [NIHE (Northern Cape)] from the Northern Cape Education Department. I hereby wish to apply for permission to conduct an investigative study using a proportional sample of mathematics student teachers from the North-West University [Potchefstroom campus and from the (NIHE) site] to facilitate the collection of statistical/non-statistical data to aid the quantitative/qualitative analyses of the study respectively. The focus of the study is to investigate the affect and concerns of mathematics student teachers during institutional learning and field practicum respectively. For purposes of the quantitative section of the study, I intend the control sample to comprise only of the first to third year mathematics student teachers from the Potchefstroom campus. Part of the empirical study will be conducted during the first and second semester teaching practice sessions for the academic year 2011 and the necessary arrangements will be made to ensure the delivery and collection of the fixed-items questionnaire to both sites timeously. I would also wish to address the participants (mathematics student teachers and lecturers) before the commencement of the empirical investigation and will schedule my availability to both Potchefstroom and Kimberley sites. I sincerely hope that this request would be considered in a favourable manner.

Kind regards.

Nazir Hassan (Student Number: xxxxxxxx)

nhassan@xxxxxx.co.za

cell number: xxxxxxxxxxxx

APPENDIX G

AN EXEMPLARY PROGRAMME FOR A MATHEMATICS LESSON

CORE CONTENT	LESSON PHASE ATTRIBUTES
<p><u>Introduction Phase</u> Mention only the <i>core content</i> (in this column) that will be dealt with in this phase.</p> <p>Do not write (in this column) what the teacher/learner will be doing, rather give the subject matter that will be dealt with during this phase</p>	<p><u>SET ESTABLISHMENT / SET INDUCTION</u></p> <p><u>Step 1: Drill work</u> [As part of a set induction process towards foundational numeracy]</p> <ul style="list-style-type: none"> ■ Learners recite multiplication tables appropriate to grade. [E.g. Grade 7 =13 times table or Grade 10 = 17 times table] ■ Teacher directs this activity. <p><u>Step 2: Focus on foundational aspects of numeracy</u></p> <ul style="list-style-type: none"> ■ Learners must read out a mathematics riddle/puzzle that they must solve mentally and explain verbally how they got the answer OR any other suitable foundational numeracy activity. ■ Teacher directs this activity. <p><u>Step 3: Link with prior knowledge or pre-knowledge</u></p> <ul style="list-style-type: none"> ■ Brief revision by the teacher of previous lesson or pre-knowledge that will link with the lesson experience (lesson topic) from a Learning Outcome (LO) and its associated Assessment Standards (AS). ■ Learner activity under teacher’s guidance. Teacher provides remedial assistance if required. <p><u>Step 4: Link with the lesson focus of the Presentation Phase</u></p> <ul style="list-style-type: none"> ■ Activity that will link with the theme(s) in the presentation phase. ■ Teacher direct-guide-monitor activity.
<p><u>Presentation Phase</u> Mention only the <i>core content</i> (in this column) that will be dealt with in this phase.</p> <p>Do not write (in this column) what the teacher/learner will be doing, rather give the subject matter that will be dealt with during this phase</p>	<p><u>Step1: Teaching of Conceptual and Procedural Mathematical Knowledge</u></p> <ul style="list-style-type: none"> ■ Focus on teaching concept/procedure using Activities/Examples /Exercises. ■ Learners must observe what is being taught. Focus on concept development and/or concept consolidation. ■ Teacher must drill the algorithm(s) as per mathematical task or problem that is being taught during this step. ■ Teacher must facilitate learning/guide/assist/mentor learners. Teacher MUST intervene if the need arises by explaining what must be done or how it must be done. <p><u>Step 2: Learning Package: Social Context Problem</u></p> <ul style="list-style-type: none"> ■ Teacher presents topical issues or newsworthy event that must be dealt with. ■ Learners must first try to solve it first on their own/groups - must construct their own problem-solving methods. However, learners are encouraged to work on these learning packages outside the formal classroom settings at their own pace. ■ Report back: Teachers MUST direct or guide discussions on possible mathematical solutions as well as open debate on the social issues raised in these learning packages. ■ Note: One topical issue is addressed per week that is captured by two Learning packages: <i>At the beginning of the Week</i> learning package and <i>At the end of the week</i> learning package. Teacher must ensure the utilisation of these learning packages to be synchronised to the unfolding of topical, newsworthy issues within a period of real-time chronology.
<p><u>Concluding Phase</u> Mention only the <i>core content</i> (in this column) that will be dealt with in this phase.</p>	<ul style="list-style-type: none"> ■ Consolidate newly acquired knowledge by Fun Activities, Relay Race, etc. ■ Homework may be given – can start completing it in the class or as a take-home activity.

APPENDIX H

PRESERVICE TEACHER CONCERNS IN FIVE MAJOR AREAS

Source: Lotter (2004: 33)

INSTRUCTIONAL (TEACHING) CONCERNS

- Instructional Methods
- Teacher behavior to ensure student understanding
- Improve/change instruction
- Relate content to student interests
- Prior Knowledge
- Comparison to own school experience
- Interactive Learning
- Instructional Pace

ASSESSMENT CONCERNS

- Grading/test construction
- Difficulty level and amount
- Motivational tool
- Use variety
- Student cheating
- Low/high test grades
- Fair to students

PLANNING CONCERNS

- Equipment/Materials
- Preparation Time
- Time management
- State Science Standards
- Special planning
- Flexibility

CLASSROOM MANAGEMENT CONCERNS

- On/off task student behavior
- Methods to reduce student problems
- Control
- Discipline to students
- Organization
- Management style

STUDENT CONCERNS

- Engagement
- Differences
- Affective
- Understanding
- Effort
- Weak skills (math, reading)

APPENDIX I

PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT

PISA 2009 ASSESSMENT FRAMEWORK

Key competencies in reading, mathematics and science

[Source: OECD (2009: 3 & 9)]

In response to the need for cross-nationally comparable evidence on student performance, the Organisation for Economic Co-operation and Development (OECD) launched the OECD Programme for International Student Assessment (PISA) in 1997. PISA represents a commitment by governments to monitor the outcomes of education systems through measuring student achievement on a regular basis and within an internationally agreed common framework. It aims to provide a new basis for policy dialogue and for collaboration in defining and implementing educational goals, in innovative ways that reflect judgments about the skills that are relevant to adult life. PISA is a collaborative effort, bringing together scientific expertise from the participating countries and steered jointly by their governments on the basis of shared, policy-driven interests. Participating countries take responsibility for the project at the policy level. Experts from participating countries also serve on working groups that are charged with linking the PISA policy objectives with the best available substantive and technical expertise in the field of internationally comparative assessment. Through involvement in these expert groups, countries ensure that the PISA assessment instruments are internationally valid and take into account the cultural and curricular context of OECD member countries. They also have strong measurement properties, and place an emphasis on authenticity and educational validity. PISA 2009 represents a continuation of the data strategy adopted in 1997 by OECD countries. As in 2000, *reading literacy* is the focus of the PISA 2009 survey, but the reading framework has been updated and now also includes the assessment of reading of electronic texts. The framework for assessing *mathematics* was fully developed for the PISA 2003 assessment and remained unchanged in 2009. Similarly, the framework for assessing *science* was fully developed for the PISA 2006 assessment and remained unchanged in 2009.

APPENDIX J

**A SUMMARY OF THE RAW DATA FROM THE ABEV QUESTIONNAIRE
(QUALITATIVE MEASUREMENTS)**

Pre-analyses information:

- In the sample population of Group 1 (n=40), only 32 respondents completed and returned the ABEV Questionnaire.
- Only the core responses from the respondents were noted based on the relevant answers provided and the correct interpretation of the questions. In cases where answers were similar, overlapped or inferred the same perceptions, these answers were noted only once. Irrelevant and wayward answers were not taken into account for analyses.
- Coding categorisation:
 - (a) 1-11: Questions pertaining to *attitudes towards mathematics*.
 - (b) 12-19: Questions dealing with *beliefs about mathematics*.
 - (c) 20-29: Questions focusing on *emotional reactions towards mathematics*.
 - (d) 30-40: Questions based on *values about mathematics*.

1. *What aspects of Mathematics (content or didactics) do you think are most important to you as a prospective mathematics teacher?*

Criteria	Tally	%
Content	#####	$\frac{12}{32} = 38\%$
Didactics	#####	$\frac{10}{32} = 31\%$
Both (Content & Didactics)	#####	$\frac{10}{32} = 31\%$

2. *Has your attitude changed with regard to Mathematics since you have been at university? Please elaborate on your answer.*

Criteria	Tally	%	Core responses
Yes	##### #	$\frac{23}{32} = 72\%$	More comprehensive-deals with different branches of maths. Not just focused on content but on context and didactics too. More in-depth. More effort required than school maths
No	#####	$\frac{9}{32} = 28\%$	Complex nature of mathematics still remained the same. Still more focus on problem-solving.

3. *What are the main concerns about teaching Mathematics you hope your teacher-training programme will address?*

To be able to do a good job (task) / whether learners will understand what I am teaching / my ability to teach mathematics that will benefit all learners / be able to cover the work thoroughly / master the content / presenting maths lessons / using the correct methodology / address my low confidence level / content knowledge / getting learners to understand mathematics / able to integrate content and context / meet the needs of individual learners / my pedagogical content knowledge / to reach every learner / to minimize my anxiety towards mathematics / to be able to teach maths in real-life context.

4. *What impact would you like to make on your learners when teaching Mathematics during teaching practice?*

For them to develop a positive attitude towards learning maths / to establish a correct mindset / to be able to change learners' perceptions towards maths / to create an awareness of the role that mathematics play in our daily lives / help learners develop a passion for mathematics / to be able to inspire learners / broaden learners' perspectives to the world of maths.

5. *Which area in Mathematics are you least confident to teach?*

Criteria	Tally	%
Algebra	#####	$\frac{9}{32} = 28\%$
Geometry	#####	$\frac{9}{32} = 28\%$
Trigonometry	#####	$\frac{13}{32} = 41\%$
No responses to this question	#	1/32 = 3%

6. *Are you comfortable using the Mathematics Lesson Plan (of the NIHE) during teaching practice?*

Criteria	Tally	%
Yes	#####	$\frac{12}{32} = 38\%$
No	#####	$\frac{9}{32} = 28\%$
No responses to this question	#####	11/32 = 34%

7. *What are your opinion on Abstract Mathematics and Contextualised Mathematics?*

Abstract: better and simpler / easier to understand / text-book focused and limited additional learning resources / content is concept and procedure-based.

Contextualised: application to real-life situations / In-depth thinking skills required / more meaningful / more relevant and it incorporates real-world problems / less focus on procedure / more context-oriented.

8. *Do you think the use of social context learning packages in a Mathematics lesson has made it more difficult or easier for learners to understand the notion of real-life context? Explain your answer.*

Criteria	Tally	%	Core responses
Difficult	#####	$\frac{11}{32} = 34\%$	Confused in how to use it / context was unfamiliar / difficult to relate to the context / can be time-consuming / content of the learning packages not linked to the content of my lesson / it tend to confused learners / language difficulty with comprehension.

Criteria	Tally	%	Core responses
Easier	#####	$\frac{17}{32} = 53\%$	Focused what was happening in the world / was able to identify with the events in real-life / better understanding of social issues / allow learners to relate their personal views in context of what was happening in the world.
No responses to this question	####	$4/32 = 13\%$	

9. *Explain why you think an attitude towards mathematics can be closely linked to the level of commitment towards Mathematics.*

Majority of respondents agreed on the following: that a positive attitude can lead to the enjoyment of the subject / right attitude can lead to less frustration towards doing or learning maths / good attitude leads to gaining confidence / a good attitude can lead to more efforts being put into mathematical tasks.

10. *Explain why you think a positive attitude towards mathematics can contribute in improving one's own mathematical ability.*

Can develop a sense of dedication / encourage learners to work harder / reflect confidence in one's own ability / able to struggle and not give up / make one more enthusiastic towards maths / become more motivated / a positive attitude can serve as a form of stimulation to do well / a positive attitude can help improve one's perception towards mathematics.

11. *What change in attitude do you think teachers experienced when changing from an old Mathematics curriculum to a new one?*

Very little as older teachers were set in their ways of teaching / for some teachers the (new) curriculum was challenging and demanding / some teachers developed a negative attitude towards the new curriculum – they viewed themselves as having received too little training and that their administrative duties at school and in the classroom had increased tremendously.

Note: A majority of the respondents were unable to furnish relevant and suitable answers to this question. This could possibly be ascribed to the fact that as student teachers they had not formed an opinion yet on the functionality of the new curriculum and might also be too young to relate to past practices of teachers already in the field.

12. *What do you think happens to a learner that experiences repeated negative emotions towards Mathematics?*

Develop a negative sense towards wanting to achieve / less committed / lose interest in wanting to do well in maths / develops low self-esteem / develops anxiety and a negative attitude towards mathematics / develop a fear for the subject / becomes intimidated by the subject / experience negative emotions.

13. *The common belief that low achievement in Mathematics can be blamed on low socio-economic status, unwillingness to learn or personal disabilities. Explain why you agree or disagree with this statement.*

Criteria	Tally	%	Core responses
Agree	#####	$\frac{11}{32} = 34\%$	Not enough learning resources at home / difficult conditions at home especially with poor families / circumstances may act as barriers to learning.
Disagree	#####	$\frac{20}{32} = 63\%$	Achievement depends on one's own ability / achievement is dependent on motivation and commitment / having a positive attitude can help overcome challenging situations / external circumstances can have little impact on a desire or willingness to succeed in life.
No responses to this question	#	$1/32 = 3\%$	

14. *Why do you think many people believe that only geniuses can be creative in Mathematics?*

They are more intellectually developed / because of being indoctrinated with that idea of who geniuses are / belief that was created in the past and perpetuated by some teachers / a positive belief in one's own ability can lead to one doing well in mathematics / stereotype notion of portraying intelligent people as geniuses.

15. *Many students and learners believe that Mathematics usually involves mainly memorization and following rules. Do you think this statement is true? Give a reason for your answer.*

Criteria	Tally	%	Core responses
True	#####	$\frac{10}{32} = 31\%$	Good for memorising concepts, formulas and rules / memorisation builds good foundations for mathematical concepts / rather memorise mathematics than trying to unravel it.
False	#####	$\frac{22}{32} = 69\%$	Involves practice too / application of rules is important too / developing one's own problem-solving skills is important / need to be expose to application to context too and not just content memorisation.

16. *Did your experiences with Mathematics help shape your beliefs about mathematics?*

All the 32 respondents (100%) agreed with the sentiment posed by this question.

17. *Explain why you think some teachers believe that they have a strong influence on the beliefs of their learners.*

Since they are in charge of teaching / that their positive disposition will have a positive influence on their learners / since they have a dominant role in the classroom / that they are the main source of information in the classroom / because of the efforts they put into teaching / that they (teachers) view themselves as role-models / that they have more life-experience / that learners will imitate their actions and beliefs.

18. *Do you agree that many teachers' beliefs and views seem to be shaped by their experiences in the classroom?*

Criteria	Tally	%
Yes	#####	$\frac{22}{32} = 69\%$
No	###	$\frac{3}{32} = 9\%$
No responses to this question	#####	$\frac{7}{32} = 22\%$

19. *Do you as a prospective mathematics teacher believe that you have received adequate training around the learner-centred and activity-based curriculum (NCS and/or CAPS)?*

Criteria	Tally	%
Yes	#####	$\frac{16}{32} = 50\%$

Criteria	Tally	%
No	#####	$\frac{16}{32} = 50\%$

20. Explain why you would agree/disagree with the view that by understanding learners' emotions towards mathematics can help you better understand their (learners') beliefs about mathematics.

A majority of respondents agreed with this statement stating the following reasons: by understanding the emotional state of learners could give them insight into their mindset and beliefs / their emotional strengths and weaknesses can influence their belief system / positive emotions a can lead to positive beliefs about mathematics /emotions are direct reflections of one's beliefs.

21. Describe the emotions you experience when doing Mathematics.

Excited (7) / Anxiety (8) / Frustrated (5) / Joy (4) / Confident (5) / Determined (1) / Mixed emotions (1) /No response (1)

22. State when your emotions are most intense:

- (a) When thinking about your own abilities when doing Mathematics.
- (b) When helping learners with mathematical problems or tasks.
- (c) When you worry whether learners have learnt what you taught them.

Criteria	Tally	%
When thinking about your own abilities when doing Mathematics.	###	$\frac{3}{32} = 9\%$
When helping learners with mathematical problems or tasks.	#####	$\frac{13}{32} = 41\%$
When you worry whether learners have learnt what you taught them.	#####	$\frac{16}{32} = 50\%$

Complete the following table by making a cross (X) next to your selection.

Statement	Emotion Construct		Scoring	
	Description of the emotion	Place (X) in this column	Tally	Ratio
23. When busy with mathematical assignments or tasks.	Enjoyment:		#####	26/32=81%
	Boredom		#####	6/32=19%
24. When waiting to write a Mathematics class test.	Anxiety		#####	21/32=66%
	Hope		#####	11/32=34%

Statement	Emotion Construct		Scoring	
	Description of the emotion	Place (X) in this column	Tally	Ratio
25. <i>When receiving the results of a Mathematics test.</i>	Relief		##### #####	21/32=66%
	Sadness		#####	10/32=31%
	No responses to this question		#	1/32=3%
26. <i>When a mathematics award is made to your fellow student, how do you feel knowing that you have also worked as hard or even harder than that student in Mathematics?</i>	Contempt		#####	12/32=38%
	Admiration		##### ####	19/32=59%
	No responses to this question		#	1/32=3%

27. *When learning Mathematics, do you experience just one type of emotion or a number of varied emotions as the learning progresses? Provide an explanation to your answer.*

Only 1 respondent stated that he/she experienced a feeling of confidence when starting and finishing a maths problem. 94% (= 30/32) expressed a perception of experiencing a varied number of emotions when learning and doing mathematics. Reasons being: during the course of doing my maths my emotions change from initially feeling frustrated to satisfaction when accomplishing the tasks / anxiety at the onset and then it changes to elation when I experience success / intense emotions at the beginning and less intense emotions at the end of an assignment or doing maths / starting off hesitant and then building up confidence when I learn maths for tests and exams / degree of difficulty of maths can make a varied number of emotions come to the fore.

28. *When encountering the social context nature of the learning packages, what is your emotional reaction towards the use of the learning packages in a mathematical activity?*

Felt a bit overwhelmed since it was the first time I was using it in my maths lesson / excitement as I wanted to see how learners would interact with these packages / anticipated anxiety – not sure whether I will be able to incorporate it successfully into my lesson / apprehensive / felt positive / I was stressed as I knew that using the learning packages in my lesson would be time-consuming as my lesson period was only 30 minutes.

29. *Describe the emotions you have experienced when mathematising topical issues or newsworthy events for use in learning packages during the second session of teaching practice.*

Uncertain if it will be suitable for use / anxious / excited / unsure / very difficult and made me frustrated / overwhelmed / extremely challenging.

30. *Say why you agree/disagree with the fact that the values of a person can determine their level of achievement or performance as well aid in their self-evaluating.*

30/32 (94%) respondents agreed. Responses: values you have in life can inspire you to perform well / values can be linked to dedication / a person with good values have good attitudes and work ethics and can lead to a high level of achievement / good values can be a source of motivation to do well / respect for one's values is important.

31. *Values about self entail identifying what values students think they have in order to be successful in mathematics. Write down TWO such values.*

The following values about self were noted from the responses: self-confidence / self-respect / self-esteem / integrity / self-belief / self-actualisation.

32. *Values about task entail the notion of what values students possesses in completing a mathematical task successfully. Write down TWO such values.*

The following values about task were noted from the responses: being goal-orientated / determination to complete a task / perseverance / satisfaction / hard work / commitment / endurance / motivation.

33. *Give the difference between beliefs about mathematics and values about mathematics as you understand it.*

Judging from the responses, it seemed that respondents found this question very difficult to answer. Some responses, however, were noted.

B: thoughts and views on maths

V: inner perceptions on maths

B: personal system of thoughts

V: ideas dealing with trust, honesty, etc.

B: pre-existing notions about mathematics

C: promote good morals and ethics when dealing with mathematics

Complete the following table by providing an appropriate example to illustrate the meaning of the predictor

<i>Values constructs in relation to the learning of mathematics</i>		
<i>Variable</i>	<i>Predictor</i>	<i>Mathematics Example (Responses noted below)</i>
<i>Values about self</i>	<i>Integrity</i>	34. Maths teacher is fair / teacher is well-prepared for lesson / to perform at the best of my ability / to be committed towards my learners / to be professional in my approach.
	<i>Sensitivity</i>	35. accept learners limitations / be patient with struggling learners / be considerate in my interaction with learners / to become aware and accommodate the different needs of my learners.
<i>Values about task</i>	<i>Perseverance</i>	36. To endeavour to complete my work / to always persevere / persist with what I am doing until I succeed / to be dedicated in helping learners until they understand the work.
	<i>Satisfaction</i>	37. express my joy when completing a maths task or assignment / to observe learners doing well / getting good results from learners / putting effort into tasks and succeeding.

38. *State the reason why you are willing (or not) to attach values to Mathematics as a life priority.*

Majority of respondents were willing to attach values to Mathematics. Responses noted were: as I have to deal with maths as part of my chosen career / I transfer values to my learners through mathematics / mathematical values can impart skills that can be used in the real-world / improve one's own life by adhering to a system of values / nature of mathematics can serve as a value-system that deals with how to cope with problems in real life and how to solve these problems.

39. *Are the values you have as a Mathematics student teacher more focused on your own survival in a mathematics classroom or on the mathematical tasks you have to perform or on what impact you may have on your Mathematics learners?*

Criteria	Tally	%
Survival	#####	$\frac{6}{32} = 19\%$
Task	#####	$\frac{10}{32} = 31\%$
Impact	#####	$\frac{16}{32} = 50\%$

40. *By considering the social context nature of the learning packages, what are the types of values that you wish to impart to your learners?*

To develop an awareness of events that are happening in the world / that maths is an integral part of real-life that has to be appreciated / to be critical and not be neutral to social, political, economic, etc. upheavals in the world / to be able to accommodate other people's views on events / to develop positive values when interacting with the issues or events captured by the learning packages / to develop a level of empathy and sympathy with people caught up in situations / to show respect and understanding to other citizens of the world /promote good social values / develop a sense of unbiasedness or independency.

APPENDIX K

DATA FROM FACTOR ANALYSIS

Notes

Output Created		23-JUL-2012 13:53:07
Comments		
Input	Data	Q:\H\Hassan_Nazir_Jun12\Hassan 1.sav
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	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	89
Missing Value Handling	Definition of Missing	MISSING=EXCLUDE: User-defined missing values are treated as missing.
	Cases Used	LISTWISE: Statistics are based on cases with no missing values for any variable used.
Syntax		<p>FACTOR</p> <p>/VARIABLES prscq1 prscq2 prscq3 prscq4 prscq5 prscq6 prscq7 prscq8 prscq9 prscq10 prscq11 prscq12 prscq13 prscq14 prscq15</p> <p>/MISSING LISTWISE</p> <p>/ANALYSIS prscq1 prscq2 prscq3 prscq4 prscq5 prscq6 prscq7 prscq8 prscq9 prscq10 prscq11 prscq12 prscq13 prscq14 prscq15</p> <p>/PRINT INITIAL DET KMO</p> <p>EXTRACTION ROTATION</p> <p>/FORMAT SORT BLANK(.20)</p> <p>/CRITERIA MINEIGEN(1)</p> <p>ITERATE(25)</p> <p>/EXTRACTION PAF</p> <p>/CRITERIA ITERATE(25)</p> <p>DELTA(0)</p> <p>/ROTATION OBLIMIN</p> <p>/METHOD=CORRELATION.</p>
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.02
	Maximum Memory Required	28260 (27.598K) bytes

Correlation Matrix

Determinant = 0.002

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.860
Bartlett's Test of Sphericity	Approx. Chi-Square
	512.767
	df
	105
	Sig.
	.000

Communalities

	Initial	Extraction
prscq1	.441	.474
prscq2	.296	.759
prscq3	.320	.271
prscq4	.520	.544
prscq5	.458	.450
prscq6	.571	.576
prscq7	.561	.551
prscq8	.531	.557
prscq9	.395	.384
prscq10	.227	.349
prscq11	.537	.611
prscq12	.465	.636
prscq13	.551	.557
prscq14	.552	.564
prscq15	.460	.447

Extraction Method: Principal Axis Factoring.

Factor Matrix

	Factor			
	1	2	3	4
prscq6	.730			.202
prscq4	.708			
prscq7	.708			
prscq8	.698			
prscq14	.688		-.253	
prscq11	.676	-.290		-.235
prscq13	.670	-.285		
prscq1	.622			.241
prscq5	.598	.245		
prscq12	.587		.293	-.409
prscq9	.546	.270		
prscq15	.518	.312	.228	
prscq3	.462	.239		
prscq2	.307	-.468	.667	
prscq10	.294	.235	.290	.351

Extraction Method: Principal Axis Factoring.

Pattern Matrix

	Factor			
	1	2	3	4
prscq13	.764			
prscq8	.760			
prscq7	.724			
prscq11	.692			-.288
prscq1	.663			.205
prscq6	.587			.280
prscq14	.530	.251	-.274	
prscq4	.499	.355		
prscq12		.818		
prscq15		.623		
prscq9		.317		.299
prscq3		.292		
prscq2			.821	
prscq10				.564
prscq5	.319			.350

Extraction Method: Principal Axis Factoring.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 17 iterations.

Structure Matrix

	Factor			
	1	2	3	4
prscq8	.742	.375		.266
prscq7	.739	.416		.244
prscq13	.731	.389		
prscq11	.718	.484		
prscq6	.702	.478		.467
prscq4	.671	.610		
prscq14	.662	.554	-.278	.223
prscq1	.652	.300		.351
prscq5	.519	.475		.501
prscq12	.422	.784		
prscq15	.357	.652		.335
prscq9	.439	.511		.448
prscq3	.377	.445		.327
prscq2	.273	.222	.813	
prscq10		.236		.579

Extraction Method: Principal Axis Factoring.

Rotation Method: Oblimin with Kaiser Normalization.

Factor Correlation Matrix

Factor	1	2	3	4
1	1.000	.554	.014	.281
2	.554	1.000	-.046	.302
3	.014	-.046	1.000	-.035
4	.281	.302	-.035	1.000

Extraction Method: Principal Axis Factoring.

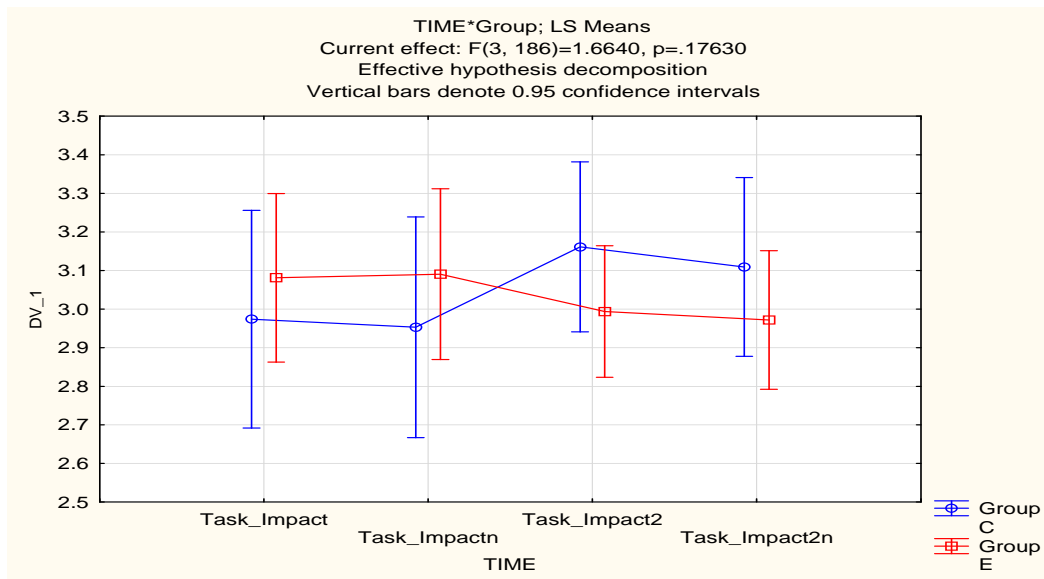
Rotation Method: Oblimin with Kaiser Normalization.

APPENDIX L

DATA FROM rANOVA

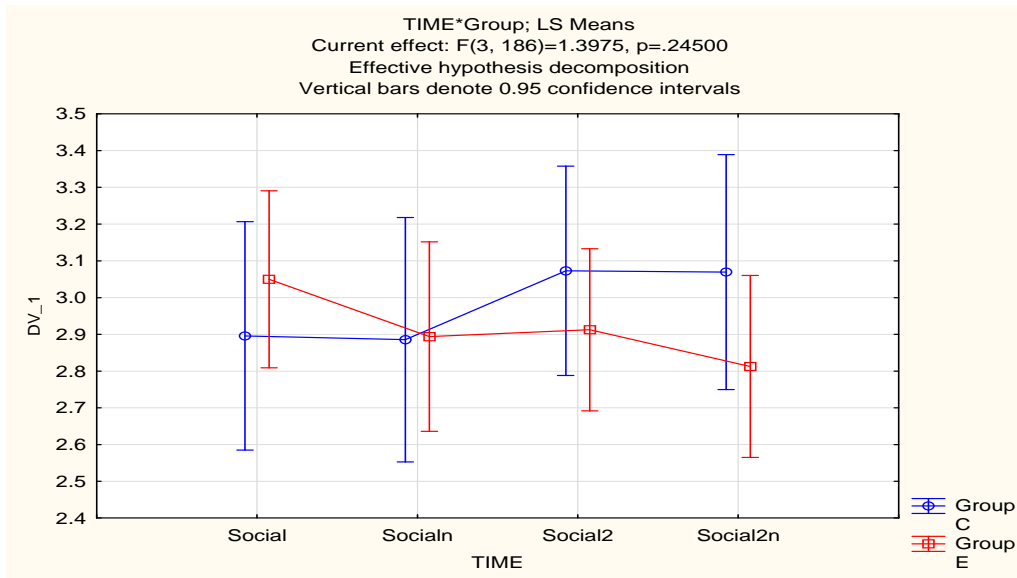
Pre-analyses information:

- Task_Impact = Pupil-benefit (Factor 1)
- Social = Self-benefit (Factor 2)
- Task_Impactn = First session measurements / Task_Impact2n = Second session measurements
- Socialn = First session measurements / Social2n = Second session measurements
- Group C = Group 2
- Group E = Group 1



Repeated Measures Analysis of Variance (Hassan 1) Sigma-restricted parameterization Effective hypothesis decomposition					
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	2220.797	1	2220.797	2488.345	0.000000
Group	0.014	1	0.014	0.015	0.901840
Error	55.334	62	0.892		
TIME	0.113	3	0.038	0.164	0.920734
TIME*Group	1.148	3	0.383	1.664	0.176300
Error	42.777	186	0.230		

TIME*Group; LS Means (Hassan 1)							
Current effect: F(3, 186)=1.6640, p=.17630							
Effective hypothesis decomposition							
Cell No.	Group	TIME	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	C	Task_Impact	2.973958	0.141140	2.691824	3.256092	24
2	C	Task_Impactn	2.953125	0.143007	2.667257	3.238993	24
3	C	Task_Impact2	3.161458	0.110122	2.941328	3.381588	24
4	C	Task_Impact2n	3.109375	0.115917	2.877661	3.341089	24
5	E	Task_Impact	3.081250	0.109326	2.862710	3.299790	40
6	E	Task_Impactn	3.090625	0.110773	2.869193	3.312057	40
7	E	Task_Impact2	2.993750	0.085300	2.823238	3.164262	40
8	E	Task_Impact2n	2.971875	0.089789	2.792390	3.151360	40



Repeated Measures Analysis of Variance (Hassan 1)					
Sigma-restricted parameterization					
Effective hypothesis decomposition					
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	2087.248	1	2087.248	1629.185	0.000000
Group	0.244	1	0.244	0.190	0.664329
Error	79.432	62	1.281		
TIME	0.365	3	0.122	0.342	0.795033
TIME*Group	1.490	3	0.497	1.397	0.245002
Error	66.117	186	0.355		

TIME*Group; LS Means (Hassan 1)							
Current effect: F(3, 186)=1.3975, p=.24500							
Effective hypothesis decomposition							
Cell No.	Group	TIME	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	C	Social	2.895833	0.155574	2.584845	3.206822	24
2	C	Socialn	2.885417	0.166465	2.552658	3.218175	24
3	C	Social2	3.072917	0.142589	2.787884	3.357949	24
4	C	Social2n	3.069444	0.159905	2.749799	3.389089	24
5	E	Social	3.050000	0.120507	2.809109	3.290891	40
6	E	Socialn	2.893750	0.128943	2.635996	3.151504	40
7	E	Social2	2.912500	0.110449	2.691715	3.133285	40
8	E	Social2n	2.812500	0.123862	2.564904	3.060096	40

APPENDIX M

DATA FOR MEAN, STANDARD DEVIATION AND EFFECT SIZES: SESSION 1 AND SESSION 2

SESSION 1: Group 1 (Experiment)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean	Effect size
Pair 1	prscq1	3.0500	40	.87560	.13844	0.13
	poscq1	3.1750	40	.95776	.15144	
Pair 2	prscq2	2.5000	40	.90582	.14322	0.03
	poscq2	2.4750	40	.93336	.14758	
Pair 3	prscq3	3.2750	40	.93336	.14758	0.26
	poscq3	3.0250	40	.94699	.14973	
Pair 4	prscq4	3.2500	40	.89872	.14210	0.11
	poscq4	3.1500	40	.94868	.15000	
Pair 5	prscq5	3.1250	40	.91111	.14406	0.11
	poscq5	3.2250	40	.91952	.14539	
Pair 6	prscq6	3.0250	40	.94699	.14973	0.00
	poscq6	3.0250	40	1.04973	.16598	
Pair 7	prscq7	2.9750	40	.83166	.13150	0.00
	poscq7	2.9750	40	.83166	.13150	
Pair 8	prscq8	2.9750	40	.89120	.14091	0.03
	poscq8	3.0000	40	.87706	.13868	
Pair 9	prscq9	2.7500	40	1.00639	.15912	0.11
	poscq9	2.6250	40	1.12518	.17791	
Pair 10	prscq10	2.2750	40	1.01242	.16008	0.05
	poscq10	2.3250	40	.99711	.15766	
Pair 11	prscq11	3.2500	40	.95407	.15085	0.13
	poscq11	3.1250	40	.88252	.13954	
Pair 12	prscq12	3.0500	40	1.10824	.17523	0.04
	poscq12	3.0000	40	1.15470	.18257	
Pair 13	prscq13	3.1750	40	.98417	.15561	0.13
	poscq13	3.3000	40	.82275	.13009	
Pair 14	prscq14	2.9500	40	.84580	.13373	0.02
	poscq14	2.9750	40	1.02501	.16207	
Pair 15	prscq15	3.1250	40	1.01748	.16088	0.20
	poscq15	2.9250	40	1.02250	.16167	

SESSION 1: Group 2 (Control)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean	Effect size
Pair 1	prscq1	3.0204	49	.85366	.12195	0.05
	poscq1	2.9796	49	.80337	.11477	
Pair 2	prscq2	2.2449	49	.94716	.13531	0.02
	poscq2	2.2653	49	1.03633	.14805	
Pair 3	prscq3	3.2245	49	.89595	.12799	0.14
	poscq3	3.1020	49	.74288	.10613	
Pair 4	prscq4	3.2653	49	.86061	.12294	0.21
	poscq4	3.0612	49	.96627	.13804	
Pair 5	prscq5	3.0204	49	.82890	.11841	0.02
	poscq5	3.0408	49	.81545	.11649	
Pair 6	prscq6	2.8163	49	.99317	.14188	0.16
	poscq6	2.6531	49	.87918	.12560	
Pair 7	prscq7	2.8776	49	.97110	.13873	0.08
	poscq7	2.7959	49	.86553	.12365	
Pair 8	prscq8	2.8163	49	.90539	.12934	0.19
	poscq8	3.0000	49	.95743	.13678	
Pair 9	prscq9	2.7551	49	.92490	.13213	0.10
	poscq9	2.6531	49	1.05180	.15026	
Pair 10	prscq10	1.9796	49	.94626	.13518	0.50
	poscq10	2.4694	49	.98111	.14016	
Pair 11	prscq11	3.1633	49	.58974	.08425	0.13
	poscq11	3.2653	49	.78463	.11209	
Pair 12	prscq12	2.7551	49	.92490	.13213	0.24
	poscq12	2.9796	49	.77701	.11100	
Pair 13	prscq13	2.9388	49	.77482	.11069	0.11
	poscq13	3.0204	49	.74972	.10710	
Pair 14	prscq14	2.9796	49	.80337	.11477	0.16
	poscq14	3.1224	49	.88111	.12587	
Pair 15	prscq15	3.0204	49	.94626	.13518	0.04
	poscq15	3.0612	49	.96627	.13804	

SESSION 2: Group 1 (Experiment)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean	Effect size
Pair 1	prsc1	2.9000	40	.81019	.12810	0.11
	posq1	3.0000	40	.87706	.13868	
Pair 2	prsc2	2.5000	40	.96077	.15191	0.08
	posq2	2.4250	40	.93060	.14714	
Pair 3	prsc3	3.2000	40	.72324	.11435	0.22
	posq3	2.9750	40	1.02501	.16207	
Pair 4	prsc4	3.1000	40	.84124	.13301	0.08
	posq4	3.0250	40	.94699	.14973	
Pair 5	prsc5	3.0000	40	.81650	.12910	0.03
	posq5	3.0250	40	.89120	.14091	
Pair 6	prsc6	2.9000	40	.90014	.14233	0.03
	posq6	2.9250	40	.82858	.13101	
Pair 7	prsc7	2.7750	40	.91952	.14539	0.05
	posq7	2.8250	40	.87376	.13815	
Pair 8	prsc8	2.7750	40	.80024	.12653	0.18
	posq8	2.9250	40	.82858	.13101	
Pair 9	prsc9	2.6250	40	1.03000	.16286	0.16
	posq9	2.8000	40	1.09075	.17246	
Pair 10	prsc10	2.3000	40	1.04268	.16486	0.02
	posq10	2.3250	40	1.04728	.16559	
Pair 11	prsc11	3.2500	40	.77625	.12274	0.18
	posq11	3.1000	40	.84124	.13301	
Pair 12	prsc12	2.7750	40	1.02501	.16207	0.00
	posq12	2.7750	40	1.07387	.16979	
Pair 13	prsc13	3.1500	40	.76962	.12169	0.10
	posq13	3.0750	40	.76418	.12083	
Pair 14	prsc14	3.1000	40	.77790	.12300	0.26
	posq14	2.9000	40	.70892	.11209	
Pair 15	prsc15	3.0500	40	1.01147	.15993	0.31
	posq15	2.7000	40	1.11401	.17614	

SESSION 2: Group 2 (Control)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean	Effect size
Pair 1	prsc1	3.2500	24	.60792	.12409	0.12
	posq1	3.1667	24	.70196	.14329	
Pair 2	prsc2	2.3333	24	.70196	.14329	0.37
	posq2	2.7500	24	1.11316	.22722	
Pair 3	prsc3	3.2083	24	.88363	.18037	0.05
	posq3	3.1667	24	.76139	.15542	
Pair 4	prsc4	3.2917	24	.80645	.16462	0.14
	posq4	3.1667	24	.86811	.17720	
Pair 5	prsc5	3.1250	24	.74089	.15123	0.12
	posq5	3.2500	24	1.03209	.21068	
Pair 6	prsc6	3.1667	24	1.04950	.21423	0.40
	posq6	2.7500	24	.89685	.18307	
Pair 7	prsc7	3.0833	24	.97431	.19888	0.13
	posq7	2.9583	24	.90790	.18532	
Pair 8	prsc8	3.0417	24	.75060	.15322	0.00
	posq8	3.0417	24	.90790	.18532	
Pair 9	prsc9	3.0417	24	.80645	.16462	0.08
	posq9	2.9583	24	1.08264	.22099	
Pair 10	prsc10	2.2917	24	.75060	.15322	0.65
	posq10	2.8750	24	.89988	.18369	
Pair 11	prsc11	3.1667	24	.63702	.13003	0.24
	posq11	3.3333	24	.70196	.14329	
Pair 12	prsc12	2.9167	24	.92861	.18955	0.18
	posq12	3.0833	24	.82970	.16936	
Pair 13	prsc13	3.0417	24	.55003	.11228	0.05
	posq13	3.0833	24	.77553	.15830	
Pair 14	prsc14	3.2500	24	.73721	.15048	0.17
	posq14	3.3750	24	.64690	.13205	
Pair 15	prsc15	3.0870	23	1.04067	.21700	0.04
	posq15	3.0435	23	.92826	.19355	

APPENDIX N
DATA ON RELIABILITY

RELIABILITY

Factor 1: CONCERNS ABOUT PUPIL-BENEFIT

Scale: ALL VARIABLES

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Inter-Item Correlations	.491	.373	.597	.224	1.601	.003	8

Item-Total Statistics

Factor 1 items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
prscq13	21.1797752809	20.899	.669	.481	.869
prscq8	21.3370786517	20.635	.687	.491	.867
prscq7	21.3033707865	20.418	.707	.527	.865
prscq11	21.0224719101	21.749	.653	.484	.871
prscq1	21.1910112360	21.611	.588	.354	.877
prscq6	21.3146067416	20.332	.657	.490	.870
prscq14	21.2584269663	21.580	.630	.413	.873
prscq4	20.9662921348	21.124	.642	.428	.871

Factor 2: CONCERNS ABOUT SELF-BENEFIT

Case Processing Summary

		N	%
Cases	Valid	89	100.0
	Excluded ^a	0	0.0
	Total	89	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha for factor 2	Cronbach's Alpha Based on Standardized Items	N of Items
.687	.685	4

	Mean	Minimum	Maximum	Range
Inter-Item Correlations	.352	.280	.490	.209

Item-Total Statistics

Factor 2 items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
prscq12	9.0674157303	4.268	.567	.333	.555
prscq15	8.8876404494	4.669	.489	.268	.609
prscq9	9.2022471910	4.913	.436	.198	.643
prscq3	8.7078651685	5.232	.391	.154	.669

Factor 3: One-item factor (Item 2). Insignificant to analyse statistically.

Factor 4: Two-item factor (Items 5 and 10)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.392	.394	2

	Mean	Minimum	Maximum
Inter-Item Correlations	.246	.246	.246

	Scale Mean if Item Deleted
prscq5	2.1123595506
prscq10	3.0674157303