Cape Peninsula
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An investigation of a mathematics intervention programme for first year at risk student teachers

by

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DECLARATION

I, Subethra Pather, declare that the contents of this dissertation represent my own unaided work, and that the dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

ABSTRACT

This study was prompted by concerns regarding the state of mathematics teaching and learning in the South African education system. One of the contributory factors to this situation is the lack of qualified and competent mathematics teachers. The problem is exacerbated by matriculants who enter teacher education programmes with a poor grasp of mathematical concepts and, in some cases, an associated dislike for the subject. Such students are described as being *at risk* of failing their first year mathematics courses in the teacher education programme. Although these *at risk* students are exposed to mathematics education within teacher education programmes, many of them graduate and return to the classroom, without having overcome their innate dislike for the subject. This has resulted in a vicious cycle in which newly graduated teachers return to the classroom and continue to contribute to the production of matriculants who produce poor mathematics results and have an aversion for the subject.

This dissertation reports on a case study of first year *at risk* student teachers studying towards a Bachelor of Education (GET phase) at a South African university. The study investigated how a mathematics intervention programme (MIP), shaped student teachers' perceptions of learning and teaching mathematics. The theoretical background to the research problem was acquired by examining four areas of the following literature, viz. students' perceptions of learning and teaching mathematics; effective mathematics intervention programmes; theoretical perspectives of learning and teaching strategies associated with mathematics; and activity theory as a theoretical framework in examining the study of learning activities of student teachers.

The empirical investigation which was underpinned by an interpretivist paradigm collected and analysed qualitative data from amongst a sample of the student teachers in the MIP. The principal source of evidence was interview transcripts, which was supplemented by test scores, and written and graphical reflections of the student teachers experiences. Activity theory was used as a lens to analyse the evidence. The research findings are therefore contextualized within an activity theory (AT) framework.

Insofar as the *outcomes* of the MIP are concerned, the evidence confirms that the *at risk* student teachers' perceptions of learning and teaching mathematics, in the sample that was selected for the study, had changed. There are three indicators of this, namely: the results of the final component of the interviews during which the subjects' responses, through the use of sort cards, indicate that their motivation, attitude and confidence to learn mathematics had improved since they commenced participating in the MIP; the improved mathematics marks amongst the subjects; and the written and graphical reflections of the subjects on their

mathematics experiences in the MIP which portrayed a positive attitude towards mathematics and mathematics learning. The results also reveal that the student teachers' activities within the various components of the activity system did not exist in isolation from one another but rather within a system of dynamic and continuous change. Thus the usefulness of AT is borne out.

This study concludes that the mathematics intervention programme had a positive effect on the *at risk* student teachers' perceptions with regard to the following: Firstly, improving the student teachers' attitudes to, and level of confidence in learning mathematics. Secondly by providing student teachers an opportunity to be exposed to teaching strategies that could be used when conducting mathematics lessons during practice teaching or as future mathematics teachers. Thirdly, improving student teachers' mathematics performance.

Overall the study provides insight into how interventions can work in elevating the confidence of at risk students in a South African context. In particular the study highlights that it is indeed possible to break the vicious cycle of returning graduated student teachers with negative perceptions of mathematics into our classrooms.

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DEDICATION

To Amma & Papa:

You raise me up, so I can stand on mountains;
You raise me up, to walk on stormy seas;
I am strong, when I am on your shoulders;
You raise me up: To more than I can be.

Josh Groban

To my parents, Bobby and Radha Padayachee for their unconditional love, support and guidance.

To my husband, Shaun and sons Hushav and Nishen who've given life new purpose and meaning.

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This dissertation reports on a case study of first year *at risk* student teachers studying towards a Bachelor of Education (GET phase) at a South African university. The study investigated how a mathematics intervention programme (MIP), shaped student teachers' perceptions of learning and teaching mathematics. The theoretical background to the research problem was acquired by examining four areas of the following literature, viz. students' perceptions of learning and teaching mathematics; effective mathematics intervention programmes; theoretical perspectives of learning and teaching strategies associated with mathematics; and activity theory as a theoretical framework in examining the study of learning activities of student teachers.

The empirical investigation which was underpinned by an interpretivist paradigm collected and analysed qualitative data from amongst a sample of the student teachers in the MIP. The principal source of evidence was interview transcripts, which was supplemented by test scores, and written and graphical reflections of the student teachers experiences. A qualitative data analysis software package facilitated the analysis of the evidence, and activity theory was used as a lens to analyse the evidence. The research findings are therefore contextualized within an activity theory (AT) framework. The value of AT to this study is that it provided the means to examine the core of the MIP, explore different facets of the programme, and obtain insight into aspects of how the MIP environment contributed to the *at risk* students teachers' learning and teaching of mathematics.

Insofar as the *outcomes* of the MIP are concerned, the evidence confirms that the *at risk* student teachers' perceptions of learning and teaching mathematics, in the sample that was selected for the study, had changed. There are three indicators of this, namely: the results of the final component of the interviews during which the subjects' responses, through the use of sort cards, indicate that their motivation, attitude and confidence to learn mathematics had improved since they commenced participating in the MIP; the improved mathematics marks amongst the subjects; and the written and graphical reflections of the subjects on their mathematics experiences in the MIP which portrayed a positive attitude towards mathematics and mathematics learning.

The results also reveal that the student teachers' activities within the various components of the activity system did not exist in isolation from one another but rather within a system of dynamic and continuous change. Thus the usefulness of AT is borne out. As a result of using the AT framework as a lens for analysis and understanding, the investigation was able to dissect the MIP across all the components of its activity and also examine the relationships between the components. The results of this study were therefore enriched by the useful insights that were obtained through this process. This in turn provided a more holistic understanding of how the MIP influenced a change in the student teachers perceptions of learning and teaching mathematics.

This study concludes that the mathematics intervention programme had a positive effect on the *at risk* student teachers' perceptions with regard to the following: Firstly, improving the student teachers' attitudes to, and level of confidence in learning mathematics. Secondly by providing student teachers an opportunity to be exposed to teaching strategies that could be used when conducting mathematics lessons during practice teaching or as future mathematics teachers. Thirdly, improving student teachers' mathematics performance.

Overall the study provides insight into how interventions can work in elevating the confidence of at risk students in a South African context. In particular the study highlights that it is indeed possible to break the vicious cycle of returning graduated student teachers with negative perceptions of mathematics into our classrooms.

Chapter One

Orientation to the research

1.1 Introduction

Higher Education Institutions (HEIs) in South Africa have been requested by the Department of Education to improve throughput rates of students (Department of Education, 2001:4). This has posed a serious challenge for universities as they have to contend with students who enter the tertiary education system bearing the scars of apartheid education. Even though South Africa is now fourteen years into post-apartheid transformation, there are still a large number of students who matriculate at schools that do not provide adequate preparation for higher education. This is due in part to resource constraints such as, inadequate classrooms, a lack of learning materials, large class sizes and unqualified or under-qualified teachers. As a result many students who enter higher education are *at risk* of failing due to their poor grounding within the school system. This study acknowledges this challenge and considers ways in which under-prepared or at risk students can be supported at tertiary level.

In this study *at risk* is understood to be a student who risks academic failure because his or her skills, knowledge, motivation and academic abilities are significantly below that of a typical student (Maxwell, 1997). The inadequate preparation of university students in key subjects such as mathematics and science (Surty, 2005) has been a cause of much concern to the academic fraternity. The lack of adequately qualified teachers in these subjects has been cited as one of the contributory factors in this regard (Asmal, 2002). Thus HEIs which offer teacher education programmes have an important role to play in addressing this problem.

One of the unfortunate consequences of the foregoing situation is that many matriculants enter teacher education programmes with a poor grasp of mathematical concepts and, in some cases, an associated dislike for the subject. Although these students are exposed to mathematics education within teacher education programmes, many of them graduate and return to the classroom, without having overcome their innate dislike for the subject (Setati, 2004). This has resulted in a vicious cycle in which newly graduated teachers return to the classroom and contribute to the production of matriculants who have an aversion for mathematics.

Academics involved in mathematics education programmes at teacher education institutions have a responsibility to break this cycle. A variety of interventions, especially at first year level, have been designed and implemented to deal with the situation. An example of one such intervention was introduced at the Cape Peninsula University of Technology (CPUT) in the Faculty of Education and Social Sciences. This faculty has designed and implemented a Mathematics Intervention Programme (MIP) to address the poor grounding of mathematics skills amongst their first year at risk BEd (GET)[1] students. The MIP at CPUT and the associated concerns of preparing student teachers as able teachers of mathematics form the backdrop of the study reported on in this dissertation.

1.2 Background to the research problem

South Africa has 12 million learners, approximately 366 000 educators and approximately 28 000 schools (Garson, 2005). The majority of schools are in provinces that are predominantly rural, viz. Eastern Cape, KwaZulu Natal and Limpopo (Chisholm, 2004). The challenge facing the education system is to address a range of backlogs inherited from the apartheid era. With regards to mathematics teaching and learning, there are at least four problems that need to be addressed:

[1] BEd is a four year pre-service teaching degree. Students in the BEd programme are preparing to be teachers in the General Education and Training band i.e. (grade R to grade 8).

- *Low numeracy levels of learners:* The Third International Mathematics and Science Study (TIMSS) which was conducted in 1995 and the TIMMS-Repeat test of 1999 reveal that South African learners have achieved below average scores in numeracy, both nationally and internationally (Howie, 2001; Asmal, 2002). The results obtained from the 1995 test indicate that South Africa received a score of 275 points out of 800. This was significantly below the international score of 487 points. For the repeat test done in 1999, a total of 225 schools from all nine provinces were randomly selected. More than 8000 grade eight learners were included in the international dataset for the analysis. Once again South Africa performed poorly when compared to participating countries, which included Australia, Bulgaria, Cyprus, Finland, Indonesia, Thailand, Jordan, Lithuania, Tunisia, England, Hungary, Singapore and Turkey. In examining these two tests no real difference in the pupils' performance was noted over the years (Howie, 2001). South Africa when compared to other African countries like Tunisia, Mauritius, Malawi, Zambia and Senegal ranked last in average numeracy scores against a set of internationally defined learning competencies (Asmal, 2002).

- *Small percentage of grade twelve learners attempting mathematics and the low pass rate amongst these learners:* In examining the mathematics Senior Certificate results during a five-year period from 1999 to 2003, the Department of Education (DoE) notes that the total number of senior certificate candidates attempting mathematics has never exceeded 60%. This implies that more than 40% of all candidates did not take mathematics at any level (Pandor, 2005). The DoE also found that the number of candidates taking mathematics at higher grade level over the five year period has never exceeded 10% of the total candidates and the percentage that passed mathematics higher grade has only once exceeded 5% of the senior certificate candidates (Pandor, 2005).

- *The significantly large percentage of unqualified and under-qualified* *teachers teaching mathematics:* According to Crouch and Perry (2003) the number of unqualified (lower than matriculation plus diploma or degree) teachers in the system is considered to be substantially high. In 1975, 11% of educators were unqualified or under qualified. In 1985 this increased to 17% and in 1994 to 36%. Although this figure had decreased to 22% by 2000, it is still reflective of an unacceptable position. Similarly, the Education Ministry's national teacher audits found that many mathematics and science teachers had no formal, relevant training. This meant that although they were qualified as teachers, their training in mathematics and science was inadequate (Asmal, 2002). According to the DoE only 50% of the teachers teaching mathematics and science have studied the subject beyond secondary school level (Pandor, 2005).

- *Undersupply of mathematics and science teachers:* The backlog of mathematics and science teachers is estimated at approximately 40% and 44% respectively (Mangena, 2001). To solve this problem, the Minister of Education provided dedicated funding in the 2005 education budget for the training of mathematics and science teachers. The national government also recognized the need to invest in academic support, and to this end South Africa's higher education budget made provision for funds up to R267 million over a three year period (Pandor, 2005).

The foregoing paints a bleak picture of the mathematics teaching and learning environment in South Africa and underscores the need for all stakeholders, including HEIs, to collectively take action to redress the inequalities inherent in the education system. To this end, higher education practitioners are engaged in a concerted effort to ensure the throughput of skilled teachers who are adequately prepared to tackle the problems related to both low numeracy and the pass rate of grade twelve learners in mathematics. As part of this effort HEIs are attending to improving the retention and throughput rates of students.

1.2.1 The importance of academic achievement for first year dropout and retention levels at HEIs

Research has shown that the first year of academic studies continues to be the most critical or vulnerable period for students' attrition at all types of tertiary institutions throughout the world (Learning Slope, 1991; Tinto, 1993; Anthony, 2000; Morsi, Smith & DeLoatch, 2007). According to MacGregor (1991) it is also a critical period for student learning and cognitive development and reveals that greater cognitive growth occurs during the first year of the students' academic experience than during any other year.

More than half of all students who withdraw from universities do so during their first year (Tinto, 1993; Norman, 1999). To address the problem of retention, a minimum investment can support some practical approaches and interventions. According to Noel (1994), the first year experience may represent a window of opportunity for promoting student learning that would be missed if tertiary institutions do not front-load their best learning resources and educational interventions during this pivotal period at university. Tinto (2003) reveals that research with regard to conditions that foster student retention is lucid, viz., students who find support for their learning, receive frequent feedback about their performance and are actively involved in the pursuit of academic excellence, especially with faculty, staff and students, are more likely to learn and in turn more likely to stay and succeed.

Such research findings support academic intervention programmes for students in their first year of university. Therefore it is the responsibility of higher education institutions to provide effective intervention strategies to help with retention and under-prepared students (Abrams & Jernigan, 1984; Parsons, 1993; Howells, 2003).

1.2.2 The need for academic support programmes for first year students in HEIs

Previous research findings reveal that entry level university students need to make significant academic adjustments during their first year of study. Further, the fear of academic failure and mastering academic skills are amongst the major concerns of these students (Anthony, 2000; Morsi, Smith & Deloatch, 2007; Morgan, 2003; Exner, 2003).

The importance of addressing the academic adjustment difficulties of new students proactively during the first term of entering HEIs is underscored by research indicating that students who earn good grades during the first term are far more likely to persist to graduate than the first term students who do not experience initial academic success (Tinto, 1993; Seymore, 1993). Students are more likely to drop out of HEIs if they receive poor or failing grades or if they perceive a decline in their academic performance relative to their previous performances.

Furthermore, research has shown that students who receive academic support in their first year of study have improved both their academic performance and academic-efficacy (Smith, Walter & Hoey, 1992). According to Walter & Smith (1990), many first year students, particularly those students that are in most need of support, under-utilise academic support services. This is further complicated as at risk students, regardless of whether they recognise that they are experiencing academic difficulties, are often reluctant to seek help (Levin & Levin, 1991). Kagan (1992) cautions that, unless HEIs intervene to alleviate the plight of at risk students, these institutions will encounter serious problems regarding the retention of students and the maintaining of minimum educational standards. He advises that institutions should deliver academic support aggressively to students, i.e. institutions should identify the students that most need support early in their first year of study and take the support services to the students rather than wait for the students to take advantage of the services of their own accord.

1.2.3 Redesign of the school curriculum: an impetus to train more mathematics teachers

The current head of state of South Africa, President Thabo Mbeki, has consistently called for greater emphasis and investment in teaching of mathematics and science as a means of responding to the acute skills shortage in the critical sectors of the economy (Surty, 2005). The DoE has in response, reacted urgently to this call by devising a new framework for education. The Revised National Curriculum Statement (RNCS) proposed a curriculum designed to prepare all learners for the 21st century in a democratic, just and caring society, based on the values of our country's constitution (Department of Education, 2003). An Outcome Based Education (OBE) approach was chosen as the means to implement the new curriculum. Some of the aims of OBE were to make teaching and learning more flexible and integrated. Another was to create a classroom environment in which learners will feel safe and comfortable. These destined significant shifts in the way teachers were expected to conceive and execute their teaching. Consequently teachers were required to not only focus on *what* learners learn, but also on *how* they learn, the *process* of learning and on the *content* of learning.

While the RNCS document (Department of Education, 2002: 3) visualises teachers as "qualified, competent, dedicated, caring [and] able to fulfil the various roles outlined in the Norms and Standards for Educators", and foresees learners who are "confident and independent, literate, numerate, multi-skilled, compassionate…" Hardman (2007) states that there is little indication about what must be transformed in order to meet these outcomes. Parker & Adler (2005) add the RNCS projects an official policy image of desired or ideal competent specialist teachers and learners, rather than a constructed reality based in practice.

However, Hardman (2007) acknowledges that one aspect that is clear from the RNCS document is the need to develop mathematically literate students who are capable of engaging in the global market place. The

RNCS has given due attention to the promotion of mathematics numeracy amongst all learners. The view taken is that mathematical competence will contribute to the personal, social, scientific and economic development (WCED, 2005). The school curriculum thus has been redesigned to ensure increased proficiency in numeracy and since 2006 all learners are expected to study either mathematics or mathematics literacy beyond the compulsory phase of schooling.

The introduction of these strategies will inevitably challenge our education system to retain and upskill educators already in the system and to recruit and train sufficient numbers of mathematics teachers (Surty, 2005). This therefore places a greater responsibility on HEIs, especially education faculties. These faculties have a crucial role to play in addressing these challenges by ensuring the training of qualified mathematics teachers. This would have a positive impact on numeracy levels of pupils as well as the pass rate of mathematics.

1.3 The research problem

Section 1.2 highlighted the following issues in the mathematics teaching and learning environment of South Africa:

- Low numeracy amongst learners;
- Lack of qualified mathematics teachers and an undersupply of mathematics teachers which has led to student teachers entering the higher education system with a poor grounding in mathematics;
- The impetus to ensure a steady supply of mathematics teachers who are sufficiently prepared to deal with the challenges of the new curriculum; and therefore
- The need for academic support programmes at especially first year university level to ensure retention of student teachers and thus adequate throughput into the school system.

The above points to the mammoth task at hand for especially the education faculties at our HEIs in addressing the problems related to mathematics teaching and learning. However, in devising academic support strategies, these faculties also have to take into account the school-based learning experiences of their students. According to Eaton & Kidd (2005) the experiences that students have during their own formative years in the classroom as a pupil have been shown to have a major impact on their behaviour as teachers. This is supported by Setati (2004) who suggests that the primary reason why university students perceive mathematics as being difficult is because of the way they had been taught at school. In the school system low achievements and repeated failure in mathematics often results in negative attitudes and lowered confidence which in turn leads to mathematics avoidance at tertiary level and increased risk of failure (Parson, 2004).

One way to tackle poor performance in mathematics would be to positively influencing the student teachers' perceptions of learning and teaching mathematics within teacher education programmes. Without this the vicious cycle of mathematics aversion will continue to be perpetuated. The interventions in breaking this cycle, set out the broad context in which the research problem of this study is located. Specifically the study investigates how interventions, such as the MIP at CPUT, are able to influence student teachers' perceptions of learning and teaching mathematics.

1.4 Background to the implementation of the MIP at CPUT

The impact of the various problems sketched in the previous sections was also evident within the Faculty of Education and Social Sciences at CPUT. In an attempt to address these concerns the Faculty consequently decided to implement an intervention programme to deal with poor performance and attitudes in mathematics learning. Four important factors, specifically related to the BEd (GET) programme that underpinned the implementation of the MIP were as follows:

- Mathematics and Numeracy form a fundamental part of the Primary School Curriculum. All first year BEd (GET) students in the

Education Faculty are expected to take a compulsory *Introduction to Mathematics* course in their first two years of study.

- Secondly, it was found that the students' level of preparation for the first year BEd (GET), mathematics course, was especially low. Many of the students entering the faculty had either last done mathematics in grade 9 or had obtained a poor mathematics mark in Grade 12. An added concern for the faculty was the mathematical aptitude of a substantial number of adult students that were being admitted to the faculty after an extended period of absence from formal study.
- Thirdly, the rapid increase in the number of students entering the Faculty's teacher education programme, and concomitant change in the diversity of students' academic backgrounds and profiles, has made the task of preparing students for mathematics learning and teaching more difficult.
- Lastly the high drop-out rate at first year level as shown in Figure 1.1 was a major concern.

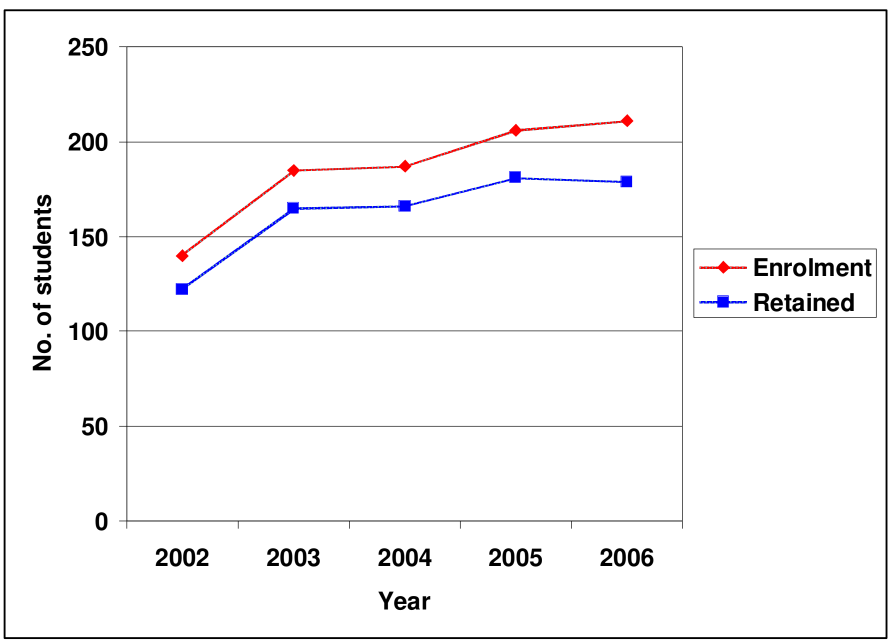

Figure 1.1: Enrolment and retention rates of 1st year BEd (General Education & Training) student teachers at the Faculty of Education and Social Sciences at CPUT (CPUT, 2007)

The MIP programme initiated was designed to be student-centred and adopted multiple teaching strategies that are grounded in constructivist learning theories, i.e. small class size, cooperative learning, slower pace of teaching, scaffolding and mentoring. The MIP presented an ideal case with which to investigate questions concerning how higher education institutions can improve the quality of mathematics teaching and learning amongst at risk student teachers. Further details regarding the design and implementation of the MIP are presented in chapter three.

1.5 The research questions

Concerns regarding at risk student teachers not being adequately prepared to learn and teach mathematics and an interest in the effectiveness of the MIP led to the following research question being identified:

How has the Mathematics Intervention Programme shaped student teachers' perceptions of learning and teaching mathematics?

The following sub-questions were subsequently identified:

i. How has the *MIP classroom environment* influenced student teachers' perceptions of learning and teaching mathematics?
ii. How have the *teaching and learning strategies* used in the MIP influenced student teachers' perceptions of learning and teaching mathematics?

1.6 Research methodology

An intensive review of the pertinent literature was undertaken, and Activity Theory (Engeström, 1987) was subsequently identified as an apt theoretical framework for the study.

Given the main research question was focused on a specific intervention programme being conducted at a particular site, the principal research strategy adopted was that of *case-study* research. An interpretivist approach was taken, and qualitative methodologies were deployed in the conduct of the study.

Participants were purposefully selected from amongst 60 first year BEd student teachers enrolled in the MIP at CPUT in 2006 based on their mathematics diagnostics test results. Semi-structured interviews were then conducted amongst the twelve student teachers between March and May 2007, using a prepared interview schedule (see Appendix **A**) as well as picture cards (see Appendix **B**).

The resultant interview transcripts formed the substantive body of data for analysis. This body of data was then supplemented with students' test scores as well as illustrative and written reflections of their mathematics experiences that were captured during a separate exercise.

NVivo (a qualitative data analysis software tool) was used to facilitate the process of content analysis. This involved identifying, coding, categorising, classifying and labelling the primary patterns in the data, and then mapping these onto an expanded activity system, i.e. an Activity Theory (AT) model.

This process produced both rich and sufficiently detailed findings in respect of the research questions outlined above. The quality of the study was enhanced through ensuring the credibility, transferability and dependability of the findings.

1.7 Research ethics

Research participants were fully informed about the purpose and procedures of the study. Written consent from the individual participants was sought before the inquiry commenced (see Appendix **C**). The participants' confidentiality and privacy were furthermore assured by the use of pseudonyms in the writing up of the dissertation. They were also assured of the integrity of the researcher to adhere to ethical research procedures and to report on the research findings in a truthful manner. The ethical guidelines adhered to are further outlined in Chapter Three.

1.8 Organisation of the study

Chapter One offers an introduction to the study, highlighting the background and context to the problem being investigated. The rationale is provided for a focus on at risk student teachers not being adequately prepared to learn and teach mathematics. The research question and sub-questions are outlined and the methodological and theoretical orientations of the study are presented.

Chapter Two provides a theoretical and analytical framework. It begins with an examination on student perceptions of learning mathematics and also a general review of mathematics intervention programmes. The literature reviewed examines two main areas, viz. theoretical perspectives of learning and teaching strategies in mathematics, and what activity theory entails. Activity theory was used both as a theoretical framework and as an analytical tool. Several studies that use activity theory to study mathematics learning are examined. The chapter concludes with a critique of activity theory.

Chapter Three outlines the research design and methodology. It details the case study, i.e. the MIP used in the study, how the empirical investigation was undertaken, as well as the procedures for analyzing the evidence that was collected. This chapter also motivates for adopting a qualitative methodological approach.

In Chapter Four the empirical evidence derived from the in-depth interviews, the written and graphical illustrations of the student teachers' reflections and test scores are described and analysed. The six components, i.e. subject, object, tools, rules, community and division of labour of the activity theory system provided a suitable framework to discuss the student teachers' learning and teaching of mathematics with regards to the MIP classroom environment, the influence of the learning and teaching strategies and the student teachers' perceptions of learning and teaching mathematics.

In Chapter Five the empirical findings of the study are interpreted and discussed. The final section concludes with recommendations and makes suggestions for further research.

Chapter Two

A review of the literature

2.1 Introduction

The research problem discussed in Chapter One provides the context for the literature review presented in this chapter. Specific issues that were identified in the research problem environment of the MIP related to interventions in teacher education environment in respect of at risk student teachers, as well as issues relating to how they learn and teach mathematics.

This chapter therefore draws on four areas of the extant literature. Firstly, I review pertinent literature dealing with students' perceptions of learning and teaching mathematics. This is followed by a brief examination of studies which reported on mathematics intervention programmes. Thirdly, and most substantively, the review focuses on constructivist theory of learning and teaching strategies associated with mathematics. Finally specific attention is given to Activity Theory (AT), as it was used by several authors in their studies of teaching and learning mathematics. The chapter concludes with a motivation as to why AT provides a suitable theoretical framework within which to undertake the empirical work of this study.

The following questions were considered during the literature review in order to explore the specific issues associated with the research problem as well as to develop an appropriate theoretical underpinning for the empirical study:

- What are student perceptions of learning and teaching mathematics?
- How do intervention programmes influence the learning and teaching of mathematics?
- How does the constructivist theory of learning influence the

learning and teaching of mathematics?

- Which existing theories provide a suitable framework for this study?

2.2 Student perceptions of mathematics learning

A *perception* refers to the action by which the mind refers its sensations to external objects as cause (Concise Oxford Dictionary, 2006). Schunk and Meece (1992) define student perceptions as thoughts, beliefs and feelings about persons, situations and events. In other studies the term perception is used synonymously with *belief* (e.g. Schoenfeld, 1994; Holt-Reynolds, 1994).

The concept *student perception* was identified as being relevant to the research problem described in Chapter One. This relevance is borne out by Schuck (1996) who argues that student teachers' perceptions held about mathematics as well as mathematics learning and teaching will influence their perceptions of studying mathematics in teacher education institutions and will also be carried with them into their career as teachers. In Schoenfeld's (1994: 57) study it was found that high school students had the following perceptions about mathematics learning:

- there is only one way to solve any mathematical problem i.e. usually the way that they have been taught by the teacher;
- to understand mathematics means simply memorizing it and applying what they have learned mechanically and without understanding;
- mathematics is a solitary activity;
- students understand mathematics in exactly the same way as they have studied it and furthermore believe that they are able to solve any assigned problem in five minutes or less.

Studies of students' perceptions of mathematics reveal that their beliefs, attitudes, understanding and experience in learning mathematics are shaped by their long exposure to rule-based instruction (Tchoshanov, Blake, Della-Pianna, Duval & Sanchez, 2001; Holt-Reynolds, 1994; Schoenfeld, 1994). As a result these perceptions have a number of implications, especially to student teachers, about what they believe mathematics is and how one should learn and teach mathematics.

If student teachers graduate from high school with the types of pessimistic perceptions identified by Schoenfield (1994) then this can have serious negative repercussions for the way in which they learn to teach mathematics. In order to help student teachers change their negative perceptions and attitude towards mathematics, Tchoshanov *et al.* (2001: 6), suggests the following philosophy of teaching and learning mathematics be inculcated in these students:

- do not be afraid of making mistakes but be afraid of repeating them;
- the process of doing mathematics is not less important than its result;
- it's better to solve one problem by using many different methods than many problems by one method;
- the purpose of mathematical problem solving is not to get the right answer but to promote students' thinking;
- giving right answers to students is dong their thinking for them;
- it doesn't matter if you know how to solve one hundred problems, it does matter how you approach them;
- fun is a derivative of challenge; and
- what we assess is what we value.

The foregoing suggests that the task of shifting student perceptions towards a more positive mode is not a simple one. This therefore has been an area in which a number of studies have been conducted. There has been a gradual but significant increase in the number of studies regarding student perceptions. Educational researchers, specifically in mathematics, have attempted to study student perceptions of learning and learning environments. Naylor & Keogh (1999) aver that this realm of research began with the study of how students construct knowledge. The increasing focus on student perceptions have made a positive contribution as they have provided teachers with valuable data with which to modify their teaching approaches (Cochran-Smith, 2003).

More recently there has been a shift by education researchers towards studying student perceptions in the classroom learning environment, as many researchers believe that students construct their own understanding of mathematical knowledge in an active learning environment (Leont'ev, 1978; Noddings, 1990; von Glaserfeld, 1995). Two examples of such studies which investigated similar environments such as the MIP in this study, are Lubinski & Otto (2004) and Tchoshanov *et al.* (2001).

Lubinski & Otto (2004) focused on a mathematics course that was designed for first year student teachers in a teacher education programme. The purpose of their study was to provide evidence that changes were occurring with student teachers in respect of their perceptions of how mathematics is learned and hence taught. The findings of the study indicate that student teachers perceptions of mathematics had been overall positively influenced by the design of the mathematics course. Important aspects of the design of the first year course included:

- Alignment of course content with the principles and standards expected for teaching school mathematics;
- Focusing on fewer topics but in much greater depth and with greater expectation of reasoning and understanding of these concepts.
- Use of teaching and learning strategies such as scaffolding to build on students previous mathematical knowledge, problem solving and group work to develop mathematical reasoning skills and sense making.
- A delineation of roles of the lecturer and student teachers. The student teachers were expected to engage in investigating, conjecturing, and justifying and then communicating their reasoning to their peers in the group and also to the class. The lecturer's role

was to provide encouragement and help the students to know that from their perspectives they are involved in a process of learning mathematics that focused on understanding mathematics.

Tchoshanov *et al.'s* (2001) study is a second example of an investigation of a similar environment as the CPUT's MIP. They conducted a study of a pilot programme in which final year student teachers were taught in a school classroom rather than the university environment. The majority of the elementary student teachers who entered the programme had previously developed negative perceptions and attitudes towards the learning and teaching of mathematics. The objective of this pilot programme was to change the student teachers' negative perceptions toward both mathematics and science learning and teaching. The following strategies were used in the pilot programme to change the student teachers' perceptions:

- mathematically friendly teaching philosophy;
- conceptually rich instructional sequencing; and
- problem solving peer/student interviews.

The overall findings of Tchoshanov *et al.* study revealed that the student teachers felt that the pilot programmes provided a good instructional setting to learn mathematics as well as to learn how to teach mathematics. The study found that student teachers preferred being taught in a school setting which enhanced their relationship with their lecturers. The students felt that they were provided with more mentoring than in a traditional university teaching environment. Lastly as a result of the positive influence on student teachers' perceptions of teaching and learning mathematics they evolved from extreme discomfort when teaching a mathematics lesson to a higher level of confidence in their ability to teach mathematics.

Both the studies discussed above allude to student teachers entering higher education programmes with perceptions already formed. The influence of students' background experiences is highlighted by Holt-Reynolds (1994) who suggests that perceptions of student teachers are to a large extent based on their personal histories. She adds that these perceptions interact forcefully with the student teachers' experiences of learning to become mathematics teachers. She proposes that teacher training programmes should take the following into consideration when teaching mathematics to student teachers:

- their prior knowledge mediates their learning;
- they constantly evaluate pedagogical ideas in terms of their own anticipated reaction to the ideas, had they been the students; and
- their beliefs remain implicit unless they are openly challenged and discussed in the teacher education situation (Holt-Reynolds, 1994).

Although the literature suggests that changing student teachers' perceptions or beliefs about mathematics learning is not easily achievable, there are studies of intervention programmes (Schuck, 1996; Bloom, 1983; Doig, McCrae & Rowe, 2003 & Gervasoni, 2005) which show that positive shifts in students' perception of mathematics is indeed possible.

2.3 Mathematics intervention programmes

According to Pearn & Merrifield (1996) effective mathematics intervention programmes require the teacher to observe and interpret the student's actions as he/she works on a set of tasks. Such programmes rely on the teacher's ability to interpret the student's mathematical knowledge and then design or adapt tasks and problems that enable the student to progress mathematically.

Education researchers who have studied mathematics intervention programmes acknowledge the importance of these programmes for mathematically at risk students. A study undertaken in North America by Schram, Wilcox, Lanier & Lappan (1988) found that student' beliefs about mathematics and the process of mathematics had changed due to their participation in a ten week long intervention programme. In Australia, Perry, Geoghegan, Home & Owen (1995) studied a mathematics intervention programme offered to primary school student teachers. The approach of this programme centred on the learning cycle of experiencing, discussing, generalizing and applying. This study revealed that the learning opportunities created in the intervention programme, helped students to develop their own mathematical background and as well as gain insight into the role of the mathematics teacher in the classroom.

However, the Australian Education Council (1991) warns that the full benefit of a mathematics intervention programme may be influenced by a range of personal characteristics and circumstances of the student and also by the quality of mathematics offered. Thus programmes that are not cognizant of such diversities may have low rates of success.

The timely detection of at risk students and their subsequent placement in interventions programmes is another success factor. According to Doig, McCrea & Rowe (2003) early detection and placement would increase student teachers' opportunity in respect of achieving learning outcomes and would also ensure successful mathematics learning and general well-being.

Gervasoni's (2005) study of a mathematics intervention programme recommended that the following should be considered when implementing an intervention programme for at risk students:

- The programme needs to be flexible in structure to meet the diverse needs of the students.
- The class size of the intervention group should be small so as to allow the teacher to be aware of each student's mathematical knowledge.
- There should be a focus on the way the mathematic curriculum is presented to the students. Learning opportunities in one mathematical domain should be provided in tandem with another.
- Intervention teachers need to:
    - provide instruction and feedback that is appropriate for each student's particular learning needs and should also based on the student's current mathematical knowledge;

- be aware of the student's learning experiences to facilitate the construction of knowledge and understanding; and
- gain professional knowledge on how to effectively customize learning experiences of students (Gervasoni, 2005 : 33-38).

A concluding remark with regard to mathematics intervention programmes is programme designers should be aware that students participating in the programme have diverse learning needs and that there is no single formula that will meet all the students' teaching and learning needs (Gervasoni, 2005).

The foregoing discussion on mathematics intervention programmes alludes to a number of issues which are concerned with learning and teaching strategies. Therefore a more in-depth understanding of the implementation of mathematics intervention programmes could be gleaned from the relevant literature dealing with theoretical perspectives of mathematics teaching and learning.

2.4 Theoretical perspectives of mathematics learning and teaching strategies

According to Nickson (2004) most theoretical perspectives of mathematics education emphasize the *social* character of mathematical learning and the importance of the *interaction* within the classroom as a mutually constructive situation where pupils learn from both the teacher and their peers. This emphasis resounds with the view of constructivist theories of learning which call for students to be active participants in their own learning (Morrone, Harkness, D'Ambrosio & Caulfield, 2004). From the foregoing and given the focus of this study on student teachers' perceptions of learning and teaching mathematics, key constructivist theory of learning and teaching strategies are explored in the following sections.

2.4.1 Constructivist theory of learning

Theories are coherent arguments that explicate and explain social processes and phenomena (Henning, 2004). Learning theories are based on assumptions about what knowledge is and how students learn. According to Gray (1997) constructivism is a view of learning based on the belief that knowledge is constructed by learners through an active mental process and that learners are builders and creators of meaning and knowledge. Pantel (1997) adds that constructivist theories do not believe knowledge is a constant for each object or event but rather that it is constructed by individuals as they interact with an object or event, in relation to their past experiences, their beliefs and their current mental structures.

The constructivist mode of teaching mathematics has only been widely accepted since the early 1980s (Steffe & Gale, 1995). According to Cobb (1994) constructivist teaching emphasizes thinking, understanding, reasoning and applying knowledge without neglecting basic skills. He adds that the classroom in this model is seen as a mini-society, a community of learners engaged in activities, discussion and reflection, be it in either small groups or whole class situations. Chaille & Britain (1991) point out that in a constructivist classroom, the teacher is the facilitator of learning and no longer the transmitter of knowledge. The facilitator of learning needs to keep in mind that instruction will vary depending on the learners' prior knowledge, current interest and level of involvement.

Matthews (2000) states that although constructivism began as a theory of learning, it has progressively expanded its domain, becoming a theory of teaching, a theory of education, a theory of original ideas and a theory of both personal and scientific knowledge. Educators utilize different aspects of constructivism differently. Two broad interpretations of constructivism can be found amongst contemporary educators i.e. personal knowledge construction and social knowledge construction (Andrew, 2006).

According to Pantel (1997), personal constructivism proposes that knowledge is ‘constructed’ individually in a person’s mind. Von Glaserfield (1995) adds that constructivism is a theory of rational knowing and that learners construct knowledge themselves on the basis of subjective experiences. This approach is very much learner-centred and assumes that the learner comes into the classroom with ideas, beliefs and opinions that need to be altered or modified by a teacher in a transactional approach. Vadeboncoeur (1997) states that this approach assumes that development is the same for all individuals regardless of race, gender, culture or social context in which learners learn.

Social constructivism expands on the idea of individuals constructing knowledge by highlighting the importance of social interaction in the learning process. Vygotsky (1978) argues that children find meaning within a social context first, before internalizing the meaning in such a way as to be able to transfer the meaning to other contexts. Richardson (1997) agrees and states the individual is situated within a socio-cultural context and individual development derives from social interactions within which cultural meaning are shared by the group and eventually internalized by the individual. Richardson (1997) adds that in this process both the individual and the environment change.

However, both these interpretations should not be practiced in isolation as Andrew (2006) maintains that students learn best when they construct their own knowledge, individually and in groups, and that knowing mathematics includes having the ability to communicate it clearly to others in a way that makes sense to the people within the classroom community.

In a constructivist mathematics classroom, the goal of instruction, as noted by Clements & Battista (1990), is as follows:

- Constructivism instruction gives pre-eminent value to the development of students’ personal mathematical ideas.
- Students are encouraged to use their own methods for solving

problems.

- Although the teacher presents tasks that promote the adoption of more sophisticated techniques, all methods are valued and supported.

Through the interaction with appropriate mathematical tasks and peers, the student's own intuitive mathematical thinking gradually becomes more abstract and powerful (Clements & Battista, 1990).

A key component in guiding students toward an interactive and constructivist approach to learning is the learning environment. The student's personal and social knowledge construction can be influenced by the learning environment created. Pantel (1997) states that constructivism propagates creating a learning environment that facilitates higher-order thinking and meta-cognition i.e. awareness of one's own cognitive abilities and the ability to apply them to the task at hand. According to Roth & Roychoudhury (1994), some features that can help create such an environment include small group discussions, student-generated research topics, active involvement and evaluations that emphasize reasoning, evidence and personal interaction rather than only correct results. Brady (2006) suggests creating a classroom environment that is committed to collaboration, caring and a dialogic mode of creating meaning. Schiefele & Csikszentmihalyi (1995) add that the classroom environment can also influence the students' motivation and enthusiasm when faced with challenging mathematical tasks.

According to Johnston (1999) teachers who base their teaching and learning on constructivist principles reject the notion that meaning can be passed onto learners via transmission. For them meaning is negotiated through cooperative social activity, discussion and debate. As Bruner (1996) states, learning is a social process in which students grow into the intellectual life of those around them. This can be linked to Vygotsky (1978) who argued that social interaction promotes development and learning. A central part of Vygotsky's approach is the role of more capable others, who facilitate the learner's development by scaffolding the learner within the Zone of Proximal Development (ZPD).

2.4.2 Vygotsky's zone of proximal development (ZPD)

The ZPD was developed by Vygotsky as a metaphor to assist in explaining the way in which social and participatory learning takes place (John-Steiner & Mahn, 1996). Vygotsky (1978: 86) states that the ZPD is the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers.

According to Sullivan (2006), Vygotsky's ZPD theory offers support to teaching prescriptions to include facilitative instruction, collaborative learning, multimodal interaction, and reflective thinking. Bockarie (2002) adds that the role of the teacher or capable peer in the ZPD is to build scaffolds, or provide a series of leading activities, which guide the learner's development process. Tharp and Gillmore's (1995) interpretation of this notion in the mathematics learning environment is that over and above the mathematics that students undertake independently, there exists a realm of mathematics that the students can only undertake with assistance from a teacher or more capable peer. They further state that when students work in the ZPD, the teacher, without reducing the complexity of the topic to be taught, assists the performance of the learner. In this environment the student is thus trained to think mathematically at a higher level.

Graham *et al.* (1998) acknowledge that the ZPD is not static, but varies as students develop, and for teachers to be effective, the teacher needs to place the problems that form the basis of the instruction in the students' ZPD. It is in this zone that the focus is on learning as a social activity, with the teacher playing a central role in the construction of knowledge and understanding. According to Kinard & Kozulin (2005) one of the important outcomes of ZPD-orientated teaching is the creation in students of the propensity toward collaborative learning, which in turn leads to greater awareness of *what they already know* and *what they still don't know*. Students thus learn how to identify what they need for successful solution of the problem and how to request the missing information from the teacher.

Ginsburg (1997) used Vygotsky's ZPD to articulate a process for responding to students' learning needs. This process required that the teacher first analyze the student's current mathematical understandings and then identify their learning potential within the ZPD. Ginsburg states that the identification of children's ZPD in mathematics will assist the teachers in providing appropriate learning opportunities for the children. The learning opportunities created should be closely aligned with the type of teaching strategies used.

2.4.3 Constructivist teaching strategies

Cooper (2007) characterises the basic principles of constructivist teaching as i) the use of prior knowledge for new learning; ii) active involvement in the learning process through problem solving; and iii) knowledge which is continually changing. He also suggests that outcomes based teaching is closely aligned to the constructivist school. The MIP which is the focus of this study also uses OBE principles in teaching mathematics. Thus, before exploring constructivist teaching strategies, i.e. collaborative learning and cognitive apprenticeship, a brief background of OBE in South Africa is necessary to place the discussion within context.

2.4.3.1 Outcomes based education

Outcomes-based Education (OBE) was introduced by the South African Government of National Unity in 1997 and implemented in 1998 as a curriculum reform intended to "democratise education and eliminate inequalities" of the old education system (Jansen, 1998: 1-2). The OBE approach replaced the content-based approach that governed South African education for the last hundred years and is in principle a learner-centred approach (Geldenhuys & Pieterse, 2005).

The focus of this mode of instruction and curriculum implementation in South African education attempted to change the content-based approach to one of continuous assessment and outcomes-based education, whereby education is based on certain outcomes needed to be achieved through teaching and learning. Although the new approach was widely welcomed, it was not accepted without noting of the various dilemmas it created (Koekemoer & Olivier, 2002).

Soudien & Baxen (1997) for example, argued that the OBE reforms proposed by the DoE were neither benign nor innocent but profoundly partial. These authors stressed that the implementation of OBE had to be more sensitive to the differences that have animated South Africa's history. Adler and Reed (2002) state that developing and implementing new curricula representing a new democratic education system within limited time frames; have produced overwhelming challenges for teacher education. Koekemoer & Olivier (2002) add that OBE is a very sophisticated approach to teaching and therefore the teacher education institutions have the responsibility and obligation to ensure that the student teachers that they train, have a sound knowledge of OBE principles and are equipped with the necessary skills that they will need to be successful teachers.

A key design feature of the new OBE approach to teaching is learner-centredness. This implies that the learners are actively involved in their learning to reach new understanding. The learners' experience of classroom practice is therefore an important dimension of the new curriculum. This tenet of the OBE approach to teaching was taken into account by the designers of the MIP at CPUT who incorporated a combination of various constructivist teaching strategies in the MIP classroom. Thus key constructivist teaching strategies that were explored to inform this study are collaborative learning (Bruner, 1996) and cognitive apprenticeship (Collins, Brown & Holum, 1991).

2.4.3.2 Collaborative learning

In identifying the link between constructivism and collaborative learning, Bruner (1996: 84) defends his claim that learning should be "participatory, proactive, communal, collaborative and given over to the construction of meanings rather than receiving them". Collaborative and cooperative learning are often equated to student-centred learning (Brady, 2006). Collaborative and cooperative learning encourages small group learning that Gillies (2002) acknowledges and concludes that it is now accepted as an important teaching-learning strategy that promotes positive learning outcomes for all students.

Such teaching strategies, according to Brady (2006), view development as social in that learning is regarded as the result of the learner's social (the social context in which learning occurs) and cultural experiences (the interactions in which they have been participants). According to Noddings (1990) small group learning strategies provide the opportunity to achieve a number of goals in mathematical learning. Several positive outcomes of such strategies can be identified (Noddings, 1990; Mathematics Association of America, 1991; Cobb, 1992; Adams & Hamm, 1996):

- Students verbalize their own mathematical thoughts.
- Students respond to questions that encourage conversation amongst students.
- They construct deeper understandings and argue convincingly for their approach among conflicting ideas and methods.
- Students construct, evaluate and modify their ideas.
- Students also gain from other students' thought processes.
- The group assists struggling peers with invalid arguments, to reach more sound mathematical conclusions.
- Students learn to assimilate new information and create new knowledge by interacting with others.
- Students solve more difficult problems than they would on their

own.

Gillies (2002), states that a review of literature on cooperative learning shows that students benefit academically and socially from small group learning. This method not only has positive effects on student achievement, but also enhances conceptual understanding, improves self-esteem, enlarges the circle of friends, increases involvement in classroom activities and improves attitudes towards learning.

In addition, Gillies's (2006) study on teachers' and students' verbal behaviour in cooperative and small group learning noted that language used by teachers in cooperative classrooms was more caring, spontaneous and personal as they work more closely with individuals and groups. The teachers' communication was also more varied and positive and disciplinary comments were reduced. Gillies also noted that students model many of their teacher's verbal behaviour and gestures in their group activities.

Vygotsky (1978) saw cooperative learning as resulting in cognitive development and intellectual growth. He elaborated by stating that what students can perform with assistance today, will allow them to perform independently tomorrow, thus preparing them to perform more demanding collaborative tasks at a later stage.

Another teaching strategy that uses cooperative learning is Cognitive Apprenticeship (CA). This strategy involves students working together towards a common goal. The teacher serves as an expert, and coaches and facilitates and also allows the students to discover things for themselves. Vygotsky (1978) calls this scaffolding and acknowledges that the release of responsibility of the teacher should be gradual and in stages. This approach to teaching is discussed further in the following session.

2.4.3.3 Cognitive apprenticeship

Cognitive apprenticeship (CA) which was developed as an instructional model can be traced back to traditional apprenticeship but with elements of schooling incorporated (Collins, Brown & Newman, 1989). CA can be used as a learning technique in any classroom, in which students learn through the help and guidance of a teacher or expert. Such guidance enables the student to achieve a task that independently would be too difficult. In schooling, the processes of thinking are often invisible to both the students and teacher. CA is a model of instruction that works to make thinking visible (Collins, 1991).

CA is structured much like the traditional apprenticeships as it includes purposeful demonstration of skills, coupled with assistance and coaching (Wilson, Teslow & Taylor, 1993). However, Darling-Hammond *et al*. (2004), state that the traditional apprenticeship differs from the CA in school settings. Whereas CA focuses on developing conceptual understandings and cognitive skills, traditional apprenticeships focus on the production of a concrete product. Thus the task or goal for traditional apprenticeships is to make something tangible whereas in CA, the task or goal is to form a process of reasoning and thinking.

Four teaching strategies associated with the CA approach have been identified in the literature:

- *Modelling:* According to Collins, Brown & Holum (1991), the modelling principle refers to a teacher or expert peer demonstrating the processes and strategies involved in performing a task and the students observing the demonstration. Schoenfeld (1983) states that when teachers explicitly demonstrate and explain specific skills and strategies, students have a better sense of how to approach the task.

- *Scaffolding:* According to Collins, Brown & Holum *(*1991), this principle refers to the teacher providing assistance in sections of the tasks that students are not completely able to manage. These scaffolds can include examples of completed tasks that allow students to see what they are working towards, sequenced steps with assistance and instruction that add up to a completed product or a variety of teaching aids, techniques, and tutoring on specific concepts or skills (Darling-Hammond *et al.* 2004).

- *Coaching:* This principle refers to the teachers providing support, feedback and observation to the students as they perform the task Collins, Brown & Holum *(*1991). Darling-Hammond *et al* (2004) acknowledge that teachers may also work to help students articulate and reflect their own thinking processes in order to build on their strengths and identify gaps in their thinking. Coaching provides assistance at the most critical level, which is the level just beyond what the student could accomplish on his/her own. Vygotsky (1978) referred to this as the zone of proximal development - ZPD. He believed that fostering development within this zone leads to the most rapid development.

- *Fading:* As the student becomes more skilled through the repetitive process of modeling, scaffolding and coaching, the feedback and instruction provided by the teacher fades until the student becomes more skilled in the task (Johnson, 1992).

Components of the CA model could be used with other teaching strategies to make thinking visible in the classroom. Schoenfeld (1985) studied methods for teaching mathematics to college students. Schoenfeld's system includes explicit modelling of problem-solving strategies, and a series of structured exercises affording learner practice in large and small groups, as well as individually. Two interesting techniques that he employed were "post-mortem analysis" and "stump the teacher". In the "post-mortem analysis" the students had to retrace the solution of recent problems, abstracting out the generalizable strategies and components. Schoenfeld carefully selected and sequenced problem-solving cases to move the students into higher levels of skills. The “stump the teacher” approach involved learners generating problems which the teacher was challenged to solve. At the beginning of each class, Schoenfeld devoted some time to solving these problems. Students witnessed occasional false starts and dead ends that the teacher encountered in arriving at a solution. During these sessions, he modelled for students not only the use of heuristics and control strategies but also emphasized the fact that one’s strategies sometimes fail.

CA is less effective when skills and concepts are taught independent of their real-world context and situation (Brown, Collins & Duguid, 1989). Students must see a real purpose for learning and have opportunities to interact with the teacher and other students in the pursuit of expertise (Darling-Hammond *et al, 2004)*.

The foregoing discussions on constructivist approaches to teaching and learning viz. ZPD, collaborative learning and CA strategies underscore a number of constructivist strategies that are pertinent to the MIP learning environment e.g. collaborative work with peers, small class size, modelling, scaffolding and student responsiveness. The discussion also highlights a mode of constructivist learning in which students are required to be *actively* involved in their learning process. There are a number of studies evident in the literature which focus on understanding the *activity* of teaching and learning mathematics, e.g. Cobb (1994), Ryder (2004), Prestage, Perks & Edwards (2005), Jarwaski (2003), and Hardman (2005 & 2007). Common amongst these studies is the use of activity theory (AT).

In recent years AT has become more prominent, as it has been able to provide researchers with both a suitable theoretical framework to study situated activity as well as a means to conduct analysis of empirical data emanating from studies of activity. Hung & Wong (2000) identify AT as being appropriate in providing a holistic perspective of teaching and learning activities and as a cultural lens through which human activity systems can be analysed (Janassen & Rohner-Murphy, 1999). Activity theory therefore is of potential importance to this study, as the research questions outlined in Chapter One imply that a substantive element of the empirical investigation requires a holistic understanding of the activities in the MIP aligned to learning and teaching of mathematics.

2.5 Activity theory (AT)

Activity theory provides a framework for co-ordinating the constructivist and socio-cultural perspectives in mathematics learning. According to Cobb (1994) activity plays a crucial role in mathematics development and learning from both a constructivist and socio-cultural perspective in mathematics education. As these are important perspectives in the research problem environment of this study, AT can therefore provide a suitable *lens* through which the research objectives set out in Chapter One could be achieved. With this in mind, in the remainder of this section, pertinent literature on AT and its relation to mathematics learning is reviewed.

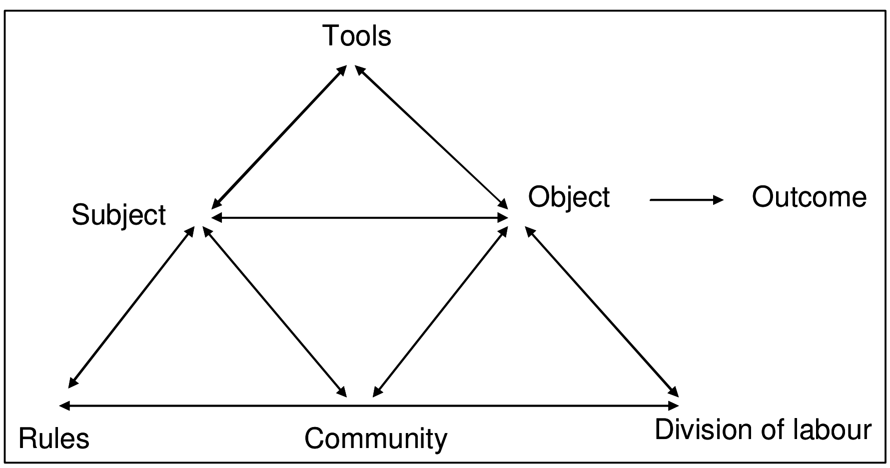

Figure 2.1 The basic triangular model of AT (Engeström 1987:78)

Activity theory was derived originally from the work of Soviet cognitive psychologists, especially Vygotsky (1986) and Leont'ev (1978). However, the well known triangular model (Figure 2.1) of AT was developed by Engeström (1987, 2001). This model has been widely used descriptively and analytically in many parts of the world. The triangular model is composed of interacting components: subject, mediating artifacts or tools, object, division of labour, community and rules. The unit of analysis in AT is the activity system. Russel (2002: 67) states that the activity system is a *flexible* unit of analysis (theoretical lens) which allows the researcher to train their *gaze* in different directions and with different levels of *magnification* to help the researcher answer the questions that *puzzle* them.

Activity theory, which is rooted in socio-cultural theory, emphasizes that if researchers want to understand what a person does, they need to take note of the context or reality in which a person operates (Bates, 2005). Thus AT provides a suitable framework for researchers to understand the actions of the actors in an environment such as the MIP. It therefore provides a model for the understanding of goal-directed social activity with its emphasis on the social rather than the individual (Brine, 2006), i.e. it provides a socio-cultural lens to facilitate the analysis of human behaviour. Such a lens lends itself to the analysis of learning processes in a mathematics classroom.

An important question that underpins the understanding of AT is *what is activity?* Human activities can be viewed as developmental processes where both individual and social levels are interlinked. According to Ryder (2004), an activity is undertaken by a human agent (subject) who is motivated toward the solution of a problem or purpose (object), and mediated by artifacts (tools) in collaboration with others (community). The structure of the activity is constrained by cultural factors including conventions (rules) and social structures (division of labour) within the context.

Cole and Engeström (1991) define an activity as a form of doing, which is intentional and directed towards the creation of a physical or mental object. This in turn leads to an outcome. Cole and Engeström's model of activity highlights three mutual relationships involved in every activity:

- the relationship between the subject and the object of the activity, which is mediated by tools that both enable and constrain the subject's action;

- the relationship between the subject and community, which is mediated by rules (explicit or implicit norms, conventions, social interactions); and
- the relationship between object and community, which is mediated by the division of labour (roles characterising labour organisation).

Cole and Engeström (1991) see relationships occurring between elements (the subject, the object and the community) within the activity as crucial to transforming the object into an outcome.

2.5.1 Origins of activity theory (AT)

Activity theory originally known as cultural-historical theory of activity was initiated in the 1920s and 1930s by a group of revolutionary Russian psychologists. A basic introduction of this theory stems from Vygotsky's notion that a human being never reacts directly to the environment (Vygotsky, 1978). Tools and signs that are part of culture mediate the relationship between the human agent and the environment. According to Vygotsky mediation through tools were more outwardly orientated and mediation through signs were more inwardly orientated, toward 'the self". However he adds that both aspects adhere in every cultural artifact and are of the same phenomenon. For Vygotsky the basic structure of human action that results from tool mediation has traditionally been pictured as a triangle, as in Figure 2.2 (Cole & Engeström, 1991).

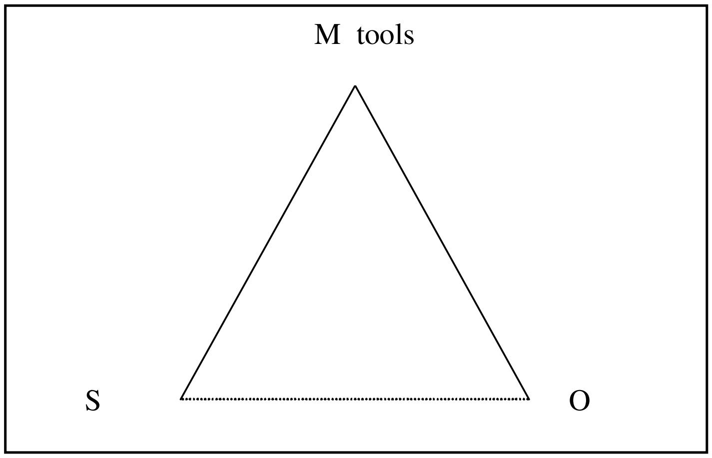

Figure 2.2: Basic mediated triangle with subject (S), object (O) and mediated means (M) (adopted from Cole and Engeström, 1991: 5)

Prestage, Perks & Edwards (2005) use the basic mediated triangle (Figure 2.2) to explore the elements that influence the student teachers' action of learning about teaching in the activity systems of schools and training partnerships. This is illustrated in Figure 2.3 where the mentor (the *subject* of the interaction) is mediating her professional knowledge for the ST or student teacher (the *object* of the mentor's action). By a mentor suggesting that learning objectives should be used, spontaneous learning may occur. However, unless there is some mediation, a deliberate pedagogical act, the ST's ideas are likely to stay unchanged, becoming routine rather than demonstrating awareness and purposeful use. This activity forms the basic unit of analysis in activity theory.

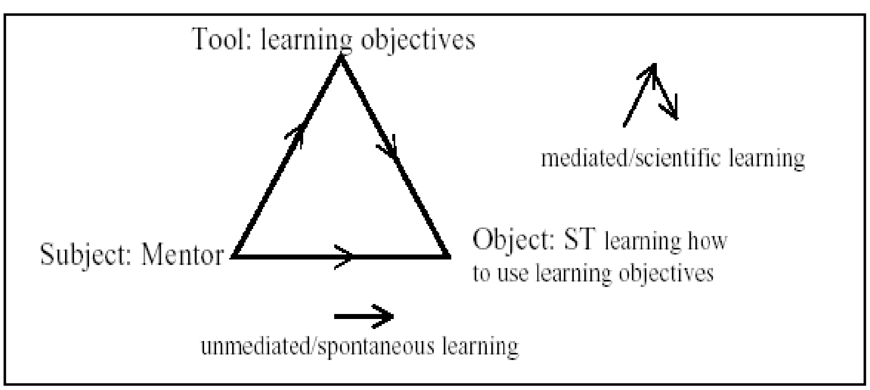

Figure 2.3: **The basic mediated triangle offers an image for learning about teaching (Prestage, Perks & Edwards, 2005**)

Vygotsky (1978) identifies the use of tools and sign operations that are learnt through social activity as a distinguishing feature of human behaviour. Learning for Vygotsky is then the internalization of sign operations that first appear external to the person and then reappear internal to the individual. While this representation opens the way towards an understanding of learning as transformation rather than transmission, it lacks an articulation of the individual subject and his/her role in the societal structure. For this reason, Engeström (1987, 1996) expanded the structure of emerging activity systems and proposed a new model in 1987. Engeström (1987) elaborated on the basic tripartite model to account for the social nature of human activity as represented in Figure 2.1.
This model still incorporates the subject, object and the tools; but it also includes other mediators of human activity, namely division of labour, rules and community, which relate to each other and other parts of the activity system. Daniels (2003) states that Engeström's AT takes the object-orientated, tool mediated collective activity system as its unit of analysis, thereby bridging the gap between the subject and the societal structure.

Jawarski's (2003) study provides a good example of how the activity theory perspective could be used to discuss knowledge and learning relating to societal significance. The project that she was engaged in involved a study of Formative Assessment Practice (FAP) and its development by teachers to enhance students' learning of mathematics. This study was mapped onto the Engeström's activity theory system using interconnected activity systems. Figure 2.4 is an exemplar of an activity system as applied to Jawarski's study: the subject was the teacher; the object was the development of formative assessment activities with the pupils; the community included other teachers in the school and other teachers in the FAP project; mediated tools included formative assessment tasks and instruments; division of labour was the self-contained classroom community; the rules included school schedules, curricular and testing requirements.

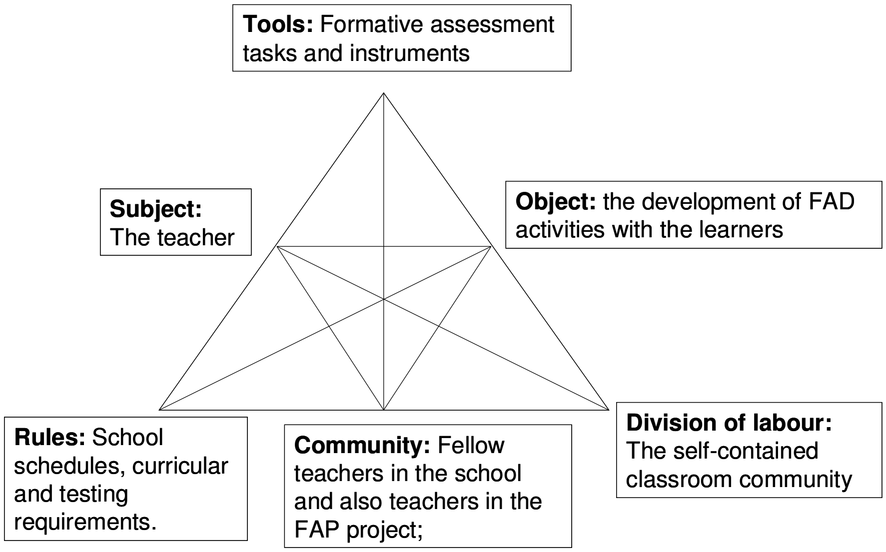

Figure 2.4: The AT framework applied to Jawarski's (2003) study on FAP and its development by teachers to enhance students' learning of mathematics

Jawarski (2003), in the same project using a second activity system, changed the subject to educator-researcher. This would also cause the object of the activity to change to be the enhanced teaching of the teacher using FAD tools, the enhanced mathematical learning of pupils of this teacher and a greater personal understanding of the educative process whereby such development occurs through classroom research. The above objectives could go beyond one simple activity theory system. It would then provide interconnected activity systems which would highlight the inter-relationship between the teacher and the educator-researcher. It would also show the connection between the researcher as insider and outsider in the classroom research process.

The activity theory framework offers consideration of individual and inter-related activity in terms of knowledge, learning, inquiry and reflection among insider and outsider and individual and community.

This study focused on a single activity system framework consisting of the six components: subject, object, tools, rules, division of labour and community. Activity theory provided this study with a lens to describe and analyse the action and interaction between and within each component of the student teachers within the social settings of the MIP classroom. This ensured a holistic view in which I could investigate the student teachers' activities in the MIP and how it has shaped their perceptions of learning and teaching mathematics.

2.5.2 Basic principles of activity theory

According to Hardman (2005) AT does not have predictive power and is best viewed as a heuristic device for identifying, examining and aiming to answer research questions related to human activity. To fully understand and comprehend the practicalities of using the AT framework it is important to understand its principles. According to Bannon (1997) AT consists of a set of basic principles that constitute a general conceptual system that can be used as a foundation for more specific theories. This section examines some of the basic principles of AT that underpin this study:

- The principle of object-orientedness;
- The principle of internal and external activities;
- The principle of tool mediation; and
- Integration of the principles

2.5.2.1 The principle of object-orientation

In AT, the principle of object-orientedness refers to the need to focus on the 'object' of activity when trying to understand human practices, since transforming the 'object' into an outcome motivates the existence of an activity (Kuutti, 1996). Humans live in a reality which is objective in a broad sense; actions undertaken by humans are directed towards a goal, which is fulfilled by an object (Bannon, 1997). According to St. Clair & Jia (2004) the idea of an object in AT is not limited to natural sciences but also to social and cultural properties.

2.5.2.2 The principle of internal and external activities

AT emphasizes that internal activities cannot be understood if they are analysed separately or in isolation from external activities, because there are mutual transformations between these two kinds of activities:

internalization and externalization (Bannon, 1997). Cole (1996) reiterates this idea in his discussion of the relationship between the 'ideal' (internal) and the 'material' (external aspects of human activity). He contends that an activity can either be internal or external but they need to be analysed together for a proper understanding to be reached. Internalisation relates to a human being's ability to imagine, consider alternative approaches to a problem and perform mental simulations. Externalisation transforms an internalized action into an external one.

2.5.2.3 The principle of tool mediation

The principle of tool mediation is extremely important and at the core of the AT. Human activity is mediated by tools both internally and externally. These tools may be signs, language, instruments, techniques or machines. Tools help to establish the relationship between human beings and their objectives for engaging in a particular activity. According to Bannon (1997) tools shape the way human beings interact with reality: shaping external activities ultimately results in shaping internal activities. Bannon adds that the use of tools is a means for the accumulation and transmission of social knowledge.

2.5.2.4 Integration of the principles

These basic principles of AT are highly intertwined with each other and it is difficult to isolate one principle from the other as there are overlaps in discussions of these concepts. Activity theory principles are associated with various aspects of the whole activity and therefore should be considered as an integrated system. A systematic application of any of these principles makes it eventually necessary to engage all the other ones (Kaptelinin & Nardi, 1997). The basic principles are also intertwined with the six components of Activity theory and will be discussed in the next section.

2.5.3 Components of the activity theory

The activity system also referred to as the activity triangle model or mediational triangle (Engeström, 1987) incorporates six components that are discussed in detail below. The model portrays the inter-relationships between the subject, object, and mediating artifacts or tools, set in the social context of rules, community, and division of labour.

According to Engeström (1987*)* the analysis is conducted from the point of view of the ***subject***, which could be an individual or group. The subject component forms the focus of the action. The subject, in achieving the object, uses mediated means or tools.

The ***object*** is the central issue to, or at, which the activity is directed and eventually leads to an outcome as a consequence of the activity.

Kuutti (1996) asserts that a ***tool*** can be anything used in the transformation process, including both material tools and tools for thinking. Tools alter the activity and are in turn altered by the activity.

Engeström (1987) intended that the ***rules*** component refer to the explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system. It defines how subjects must fit into the community.

The ***community*** for Engeström (1987) comprises multiple individuals and/or subgroups who share the same overall object and who construct themselves as distinct from other communities. The community component therefore includes the notion that an activity is carried out within a social and cultural context of the environment in which the subjects operate.

The ***division of labour*** or *roles* describes how the object of the activity relates to the community. The division of labour refers to both the horizontal division of tasks between the members of the community and the vertical division of power and status (Engeström, 1987).

The ***outcome*** of an activity is the purpose for which the object is used and hence is dependent on the meaning that is ascribed to the object. It is a more extensive range of interest than the immediate object.

2.5.4 Using the activity triangle model as a framework in this study

As a unit of analysis, the activity triangle model is flexible, as it can be used at a variety of levels in which the various components of the activity system relates to each other in a specific activity. In the context of this study an ***activity*** refers to the student teachers engaged in mathematical teaching and learning activities in the MIP. The student teachers constitute the ***subjec****t* in this study. The ***object*** of the activity is for them to enhance their te*aching and learning knowledge of mathematics. The desired* ***outcome*** would be to qualify as better equipped mathematics teachers. The ***community,*** sharing the object, include the student teacher, peers and the lecturer. The ***tools*** used in the transformation process are the various learning and teaching techniques employed by the MIP (e.g. small groups, slower pace of instruction, collaboration, class discussions, practical work and worksheets). The ***division of labour*** is between the lecturer, peers and student teacher. A set of implicit and explicit ***rules*** were identified, notable among these were: assessments, attendance, and participation.

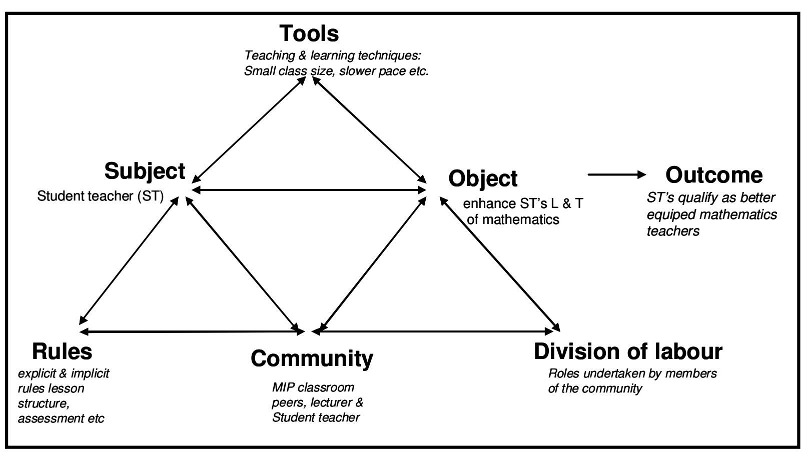

Figure 2.5: The AT framework as applied to this study

The various components of the activity system as presented above and graphically in Figure 2.5, should not be seen as static features existing in isolation from one another but rather as dynamic and continuously changing. The main focus of an AT system is on how the subject transforms the object and how the various components of the system mediate this transformation (Kuutti, 1996).

2.5.5 An overview of the application of AT in research contexts aligned to this study

Engeström's model of activity theory has been used as a research framework and a heuristic supporting innovation in a wide array of contexts including education (Engeström, 1987; Gamaroff, 1999; Roth, 2004; Hardman, 2005; Goodchild & Jaworski, 2005; Jaworski & Goodchild 2006), healthcare (Engeström, 1993 & 2000), and human-computer interaction (Kaptelinin, 1996; Dayton, 2000; Grevholm & Bergsten, 2004; Voigt & Swatman, 2006; Thorne, 2007). According to Thorne (2007) activity theory does not separate understanding (research) from transformation (concrete action), it encourages engaged critical inquiry to enact positive interventions.

Although there has been a wide range of studies on AT and education, I have drawn on a sample of four studies that use the application of AT in mathematics learning. Prestage, Perks, & Edwards (2005) used the AT framework to explore the student teachers' knowledge of mathematics learning in the social settings of the school and training institution's environment. The mediated tool used in this activity was the lesson plan. The study reviewed mathematics learning objectives/outcomes in student and student teacher learning in the context of a lesson and lesson debrief that were observed. Fitzsimons (2005) used AT to inform course design and delivery for students who needed to transform their mathematical knowledge and skills for context of use outside institutionally orientated mathematics education. Technology was used as the mediated tool to achieve the objectives of the learning process. Flavell's (2004) study reflected on an intervention programme that was designed for low performing mathematics students in the final year of study in secondary education. The mediated tools used were essay writings and solving mathematical problem exercises (micro activities). The social context and the micro activities were investigated to measure the students' knowledge of and goal directed involvement in the broader socio-cultural meaning of studying mathematics. Finally, Grove & Dale (2003) examined the use of the calculator as a mediated tool for creating and supporting the mathematics learning of young learners in the social settings of the classroom. AT was used to explore the relationships between the young learner, the calculator, the teacher and the classroom environment.

The studies mentioned above show there are a variety of approaches in which activity theory could be applied to the study of phenomena. A close perusal of these studies serves to reinforce the choice of activity theory as a framework to conduct the empirical investigation in this study. In particular the studies above serve to illustrate how AT can be used to examine individual learning in different social settings. Furthermore, whilst the context of the AT in these studies had different mediated tools, the object of the activity in all of them centers on the learning process in mathematics. This therefore underscores the usefulness of AT in understanding mathematics learning processes regardless of the specific mediated tools.

2.5.6 Critiques of activity theory

Roth (2004) argues that there are still many unsolved issues relating to activity theory. In referring to the work conducted by Daydov (1999), he lists some of these problems as relating to the nature and role of transformation in activity systems, the relation of collective and individual activity, and the relation of activity theory to other theories of human conduct.

Other authors have been critical that there are several areas in which AT has still not been applied, For example, Hardman (2005) expresses a concern that while there are numerous examples of the application of AT in interventionist research to analyse a variety of contexts, there are surprisingly few analyses dealing with the use of AT in exploratory studies at the level of the primary school classroom. She is further critical that though AT is used primarily as an interventionist tool, it struggles to track the emerging object of complex activity systems observationally.

Perhaps one of the main critiques of AT is that it has been applied within diverse disciplinary settings, e.g. product design, studies in creativity, drama, and in education. Therefore a researcher, who is unfamiliar with multi-disciplines, would find it a challenge to come to terms with the application of AT as it would require a review of studies in such a variety of contexts. On the other hand, the diversity of application of AT could also be viewed positively, in that this is demonstrative of its pliant nature and as such is easily adaptable. Roth and Lee (2007) for example refer to AT as being an accommodating framework, rather than a set of neat propositions. Indeed, this was found to be the case in considering if AT could be applied to this study. Additionally, as a sufficient number of relevant studies in education were identified in the literature surveyed, I believe there is a strong case to support primarily the use of AT as a theoretical underpinning for this study.

2.6 Conclusion

This chapter has presented a review of studies on student perceptions of learning mathematics, mathematics intervention programmes, learning theories and teaching strategies which have provided an important background and conceptual understanding of the research problem – the role of the mathematics intervention programme in shaping student teachers' perceptions of learning and teaching mathematics. In respect of the socio-cultural perspective, an often cited theoretical framework, in the form of AT was identified in the literature. In the introduction of this chapter, I referred to a paradigm shift in the South African education environment in the post 1994 era to OBE. This shift was described as being characterized by a constructivist, learner-centred approach to teaching and learning which also characterised the MIP learning environment. This in turn underscores the socio-cultural importance of the learning environment. The close alignment of AT to the socio-cultural views of the learning environment, especially Mathematics (see for example Cobb, 1994) is one of the motivating factors for using it as an underpinning framework for the study. Other reasons for the choice of AT have to do with its suitability as a holistic framework for studying a learning environment (see for example Hung & Wong, 2000) and the flexibility with which it can be applied to different research contexts (see for example Hardman, 2005). Furthermore, AT provides a means of acknowledging the "context or reality" (see Bates, 2005) of the MIP in understanding how student teachers have learnt about mathematics and the teaching thereof. Lastly section 2.5.5 above, provides evidence of the usefulness of AT in understanding mathematics learning processes regardless of the type of tools being used in a specific environment.

In the next chapter, I extend the discussion of the use of AT by discussing its use as a tool to analyse data. Chapter Three also presents an overview of the research design, and justifies the choice and use of methods and techniques to collect data to answer the research question.

Chapter Three
Research design and methods

3.1 Introduction

In the first chapter an overview of the research methodology, as applied to this study, was provided. This chapter extends the discussion and presents a more detailed account of the research process. According to Babbie and Mouton (2001), the research methodology focuses on the research process and the kind of tools and procedures to be used. Therefore details of how the empirical investigation was undertaken and the procedures for analysing the evidence that was collected are given.

At the outset, the alignment of the research methodology with the research objectives and the associated question was a fundamental consideration. I therefore reflected carefully on the purpose of the study in making the various methodological decisions. The main objective of this study was to investigate whether an intervention in higher education, such as the Mathematics Intervention Programme (MIP), was achieving a desirable outcome in respect of changing student teachers' perceptions of learning and teaching mathematics. In pursuance of this objective, the principal research question identified was: **How has the MIP shaped student teachers' perceptions of learning and teaching mathematics?** Specific sub-questions flowing from this that required investigation were:

i. How has the *MIP classroom environment* influenced student teachers' perceptions of learning and teaching mathematics?
ii. How have the *teaching and learning strategies* used in the MIP influenced student teachers' perceptions of learning and teaching mathematics?

Given the main research question was focused on a specific intervention programme being conducted at a particular site, the principle strategy adopted was that of *case-study* research. According to Merriam (1998), a case study is anchored in real-life situations and provides a holistic account of a phenomenon. The *real-life* situation, in which the research objective of this study was anchored, was the MIP, and the *phenomenon* being investigated was student teachers' experiences and perceptions of learning and teaching mathematics. These central tenets of case-study research formed the initial guiding principles for the research design.

With a case-study research strategy in mind, I set out to make further detailed methodological decisions. Babbie & Mouton's *Three Worlds of Knowledge* framework (Babbie & Mouton, 2001: 48) (see Figure 3.1 page 3) provided a suitable framework to guide further decision-making in respect of research design and concomitant methods. According to these authors, this framework is a tool that helps to organise the researcher's thinking about science and the practice of scientific research. This framework assists the researcher to integrate the research problem (World One) with the World of Science and Metascience (Worlds Two and Three). The basic tenets of the Three World Framework (Figure 3.1) are summarised from Mouton (2002 : 8-10) as follows:

World One: **Everyday life** (pragmatic interest): In World One researchers encounter problems which require investigation. The objective of such investigations usually leads to people being able to cope more effectively with everyday life. Thus it is the pragmatic interest in day-to-day living that drives individuals to acquire knowledge in World One.

World Two: **The world of science** (the methodological interest): World Two is the world of science and scientific knowledge. The search for truth or epistemic interest is the main focus of this world. Researchers rely on the body of knowledge in this world, and the tried and tested scientific practices to assist them to solve the problems identified in World One.

World Three: **The world of metascience** (the critical interest): Researchers in World Three have to constantly submit their research decisions to make choices as to which theories to select, how to measure phenomena, which research design to choose, etc. Thus it is important for a researcher to be aware of the meta-scientific aspect of philosophical influences of their research.

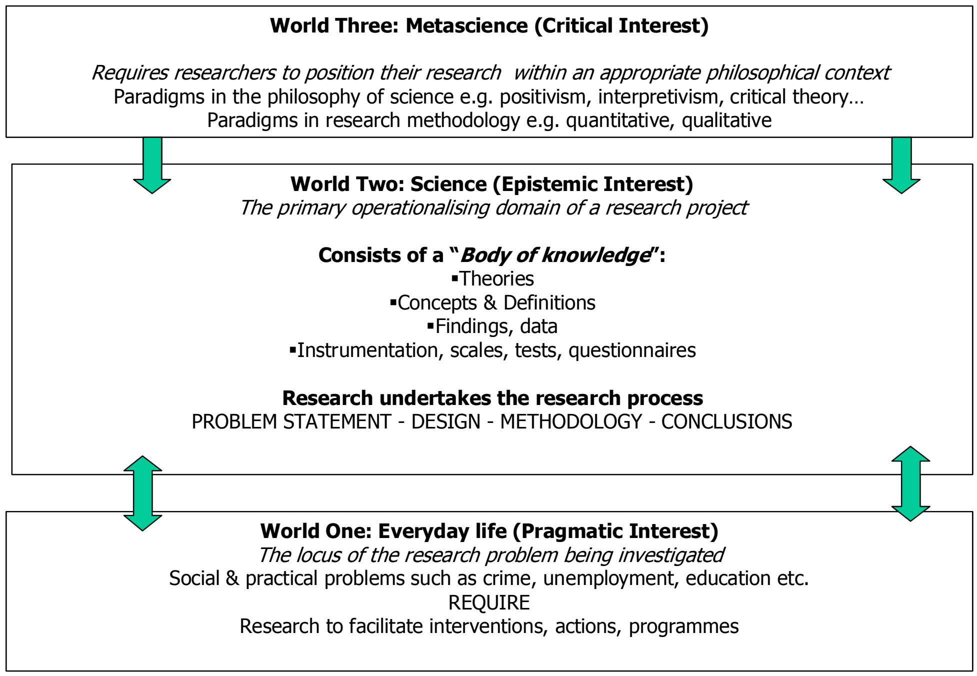

Figure 3.1: Three world framework

(Babbie & Mouton, 2001: 48)

In light of the foregoing, there were three important considerations during the early design stages of my research, viz.

- The nature of the research problem from World One: Although at this point in my research process the problem was already identified, it was clear that it was required of me to engage in deeper reflection on this problem so as to make appropriate choices regarding World Two and World Three Issues. Also an error in problem formulation may potentially lead to the wrong results or not solving the identified problem.
- Having considered my research problem, I needed to align this study within an appropriate philosophical context that would guide me towards establishing the most profound answers to my research question.
- Issues pertaining to specific research methods (World Two) would

become clearer after having considered the various options in World Three.

Consequently the next research decision concerned the underlying meta-scientific influences on my research, which is sometimes also referred to as philosophical positioning.

3.2 Philosophical assumptions of the research

There are many different positions evident in the education literature; Table 3.1 provides a summary of the different philosophical approaches that could be followed (Janse van Rensburg, 2001: 12-24).

Table 3.1: A summary on philosophical assumptions for research

Philosophical assumptions	Positivism	Post-Positivism	Interpretivism	Social Construction	Critical Science
Ontology	Stable, external reality, law-like	Stable, external reality, law-like, but can only be approximated	Internal reality of personal, subjective experience	Socially constructed reality, discourse	Critical realist, materialist
Epistemology	Objective, detached observer	Observers are subjective but need to strive for objectivity and control their bias	Empathic, observer inter-subjectivity	Suspicious, political, observer constructing versions	Inter-subjective objectivity
Methodology	Experimental, quantitative, hypothesis testing, analytical	Descriptive, interpretive, both qualitative and quantitative	Interactional, interpretive, qualitative	Often de-construction, textual analysis, discourse analysis	Participatory research, critical action research, critical ethnography & discourse analysis
Knowledge Interest	Predict, technical	Technical or practical, predict or understand	Understand, practical	Political/ Emancipatory, troubling given understanding	Empower-ment, transfor-mation

Having considered the various options, the interpretive approach was identified as being a suitable framework for this study for the following reasons:

- the ontological orientation of the interpretive approach resounded closely with the objective of this study which was focused on investigating the internal reality of student teacher's personal experiences in the MIP;

- I deemed the qualitative methodological approach to be suitable for the case study, especially since I needed to conduct an in-depth study of the small number of subjects that constituted the research population; and
- there was a two-fold knowledge interest in this study, viz. understanding aspects of teaching and learning; and secondly a practical dimension which was concerned with improving the delivery of the MIP at the chosen site.

Interpretivists acknowledge that the problem which they are researching exists in a social context, and that the most appropriate way of understanding actions of social actors may not necessarily be through numbers and rigorous statistical tests (Pather and Remenyi, 2005). Blaikie (2000: 115) offers the following view of interpretive approach:

> Interpretivists are concerned with understanding the social world people have produced and which they reproduce through their continuing activities. This everyday reality consists of the meanings and the interpretations given by the social actors to their actions, other people's actions, social situations, and natural and humanly created objects. In short, in order to negotiate their way around their world and make sense of it, social actors have to interpret their activities together, and it is these meanings, embedded in language, that constitute their social reality.

According to Blaikie, an interpretive approach not only sees people as a primary data source, but seeks their perceptions or inside view, rather than imposing on 'outsider view'. Thus Blaikie's definition of the interpretive approach aligned to my initial assessment of this study, viz. the outcomes of this study depended on how I as a researcher, interacted with the social world in order to extract the meanings and interpretations of the actors (in this case the student teachers). It was therefore important to utilise methods that would facilitate an *insider-view* of the research subjects.

Additionally, an interpretive model of research was deemed appropriate for this study as education and knowledge are socially and culturally bound together and these aspects have to be taken into consideration when a study on teaching and learning is conducted (Bessoondyal, 2005). According to Mason (2002), people, their interpretations, perceptions, meaning and understandings form the primary data sources. Interpretivism therefore supports a study which uses interview methods where, for example, the aim is to explore research subjects' individual and collective understandings, reasoning process, social norms and so on.

Mason (2002) states that a major challenge for interpretivist approaches centres on the question of how you can be sure that you are not simply inventing data, or misrepresenting the research participants' perspectives. She argues that qualitative researchers over many years have been locked in debates about this question and the issue that different qualitative approaches offer different solutions (Mason, 2002). To avoid this problem with reading 'beyond' data, interpretivist researchers from this perspective, should concentrate on utterances and recorded interactions. According to Koch (1999) interpretivist researchers argue that through carefully implementing procedures such as triangulation, a large part of the bias inherent in individual researchers can be identified, and at least to some extent controlled.

In light of the foregoing, I was satisfied that the interpretivist tradition was a suitable framework within which to undertake this study. The subsequent methodological decisions that were to be made focused on World two, i.e. the operationalisation of the investigation in the field.

3.3 Research design

The design of this study essentially comprised of a qualitative approach to conducting case study research. This approach is supported by Cohen, Manson & Morrison (2000) who argue that in the field of education case study research is most naturally suited to the interpretive paradigm.

3.3.1 Case studies

Case study research according to Harrison (2002) is more aptly described as a strategy than a method. It sets out to address the understanding of a phenomenon within its operating context. According to Nisbet & Watt (1984) (cited in Cohen, Manion & Morrison, 2000) a case study provides unique examples of real people in real situations, enabling researchers to understand ideas more clearly; and can penetrate situations in ways that are not always susceptible to numerical analysis.

The defining characteristic of a case study is its intensive investigation of a single unit (Yin, 1994). In this study the unit of investigation was the student teachers in the MIP. The case study design was employed to gain a more detailed understanding of their perceptions of learning and teaching mathematics.

The interest of case studies is in the *process* rather than in outcomes, in the *context* than in a specific variable, in *discovery* rather than in confirmation (Merriam, 1998). As such, the methods employed in the research of this study had to facilitate an investigation of the processes in respect of the teaching and learning strategies of the MIP (the *context*). Furthermore as this study was not based on pre-determined hypotheses, the methods needed to promote *discovery* of the issues implied by my investigative questions.

3.3.2 Qualitative research

All research has to consider the *type of evidence* required to answer research questions. This choice usually concerns either quantitative or qualitative evidence or a combination. For the purpose of this study I decided that the research objectives would be best achieved through the collection of qualitative evidence.

According to Strauss and Corbin (1998) qualitative research implies any type of research that produces findings not arrived at by statistical procedures or other means of qualification. They add that qualitative research pursues a deeper understanding of the human experiences focusing on the quality aspect of the human behaviour in order to explain, predict, describe and control behaviour. This aligns closely with the views of the interpretivist paradigm discussed in section 3.2.

In Table 3.2 Wiersma & Jurs (2005), descriptions of the qualitative research process are summarised and applied to this study.

Table 3.2: A description of qualitative research & its application to this study

The qualitative approach	As applied to this study
Qualitative research has its origins in descriptive analysis, and is essentially an inductive process, reasoning from the specific situation to a general conclusion;	Investigating the student teachers in the MIP class to further understand how student teachers could improve their understanding of learning and teaching mathematics.
A qualitative approach enables the researcher to observe subtle events that may be difficult to measure through other methods;	To elicit the deep feelings that student teachers may have towards a subject like mathematics may not be easy to gain just through the interview method. Therefore an additional method engaging students in tasks such as narrative writing and graphical illustrations was used to bring out their inner feelings.
Research is conducted in natural settings and the meaning derived from the research is therefore specific to that setting and its conditions;	My field work took place in the environment in which the student teachers are learning mathematics i.e. within the university and in a typical classroom situation.
This research approach emphasises a holistic interpretation and is based on the notion of context sensitivity, with the belief that the particular physical and social environment has a great bearing on human behaviour.	The student teachers were placed in an environment where they had a lecturer that was very understanding, patient and creative in teaching. All the student teachers in the intervention class were at a similar ability level with regards to their mathematical knowledge thereby allowing them to identify and interact with each other.

The description of qualitative research in Table 3.2 provided a guide in making decisions regards the specific methods to conduct the fieldwork.

3.4 Overview of the selected case

The MIP at CPUT presented an ideal environment within which to investigate the problems outlined in Chapter One. The MIP is an intervention designed by the mathematics department of the Faculty of Education and Social Sciences at CPUT. The MIP was implemented in the first year of the Bachelor of Education (GET) programme. This is a four year pre-service degree which includes compulsory practice teaching sessions twice every year. All first year BEd (GET) student teachers are expected to participate in practice teaching at selected schools. Practice teaching is divided into two sessions, four weeks each, whereby in the first session the first year student teachers are involved mainly in observation of lessons being taught and as an option could teach a lesson. However in the second practice teaching session all first year students are expected to teach a minimum of two planned lessons per day.

The following section presents a more detailed description of aspects pertaining to the design and the implementation of the MIP. The purpose of this is twofold. Firstly this discussion assists in providing context to the research design and methods discussed in this chapter. Secondly, since a case-study is the principal design strategy, a detailed account of the case is relevant.

3.4.1 Aims & objectives of the Mathematics Intervention Programme

The MIP was designed with the following aims in mind:

- to identify student teachers who were academically at risk of failing their first year BEd mathematics course;
- to assist the *at risk* student teachers to develop academic and social skills required to pass first and second year BEd mathematics; and
- to instill confidence in the student teachers to learn and teach mathematics (CPUT, 2005).

The specific objectives of the programme were to:

- provide a strong foundation in basic mathematics skills;
- develop student teachers' confidence in both learning and teaching mathematics;
- reduce anxiety and stress associated with mathematics learning and teaching;
- improve mathematics results (CPUT, 2005).

3.4.2 Identifying academically at risk students

The MIP targeted students who were at risk of failing first year mathematics. According to Maxwell (1997) students whose skills, knowledge, motivation and academic abilities that are significantly below those of a typical student enrolled in a particular study, are at risk of academic failure. Using this definition as a guide, the lecturers in the Faculty of Education and Social Sciences at CPUT, used the following criteria to select first year BEd (GET) student teachers to participate in the MIP:

- students who did not pass their grade 12 mathematics or had last done mathematics in grade 9;
- students who failed the mathematics diagnostic test administered at the beginning of the academic year; and
- adult students returning to study after a long period of absence, with or without grade 12 mathematics.

3.4.3 Implementation of the Mathematics Intervention Programme

The MIP occurred in parallel sessions to the mainstream first year BEd (GET) mathematics class and took place twice a week for the full academic year. Each period was forty five minutes in duration. The total hours allocated to the *Introduction to Mathematics* course was 36 hours for the year. However the MIP class was allocated an additional 10 hours to allow at risk student teachers time to grasp the mathematical concepts. Fundamental to the programme was the small class size. The student teachers identified as mathematically at risk of failing their first year BEd mathematics course were invited to join the MIP class. The MIP class groups ranged from ten to twelve students in a class. The class was taught by a qualified mathematics specialist. All the MIP sessions were activity-based and interactive. The pace set by the lecturer afforded the students the opportunity to ask questions and seek assistance.

The MIP followed the same syllabus (refer Appendix **F**) as the mainstream

BEd1 (GET) Introduction to Mathematics course. The subject content in the Introduction to Mathematics course consisted of the following topics:

- Numbers (Learning Outcome 1)[1]
- Number patterns (Learning Outcome 2)
- Geometry (Learning Outcome 3)
- Measurement (Learning Outcome 4)
- Data Handling (Learning Outcome 5)

The subject content for the didactics component of the mathematics course was as follows:

- The culture of the mathematics classroom.
- Constructing the number concepts in the intermediate phase.
- Teaching strategies to develop number concepts.
- Mathematics and the RNCS.
- Lesson planning in mathematics.
- Instructional sequences for teaching elementary measurement.

The learning materials used in the MIP was designed by the Education Faculty's mathematics department. With regards to evaluation and assessments, the student teachers in the intervention programme wrote the same exit examination as the mainstream mathematics class, however, different class tests designed by the MIP lecturer were administered to the intervention class. Regular feedback enabled the Academic Development Programme (ADP) co-ordinator and MIP lecturer to monitor the student's progress carefully, providing the scope for improvement in areas of weakness and building on their strengths.

This study therefore evolved out of a commitment to improve mathematics learning and teaching of the student teachers in the MIP and to begin to reverse the cycle of educational failure for mathematically at risk student

[1] see Appendix **F** for mathematics Learning Outcomes (LOs)

teachers.

3.5 Research methods

Research methods support the systematic execution of the study design. The methods discussed in this section outline the individual steps employed in the undertaking of the research process, viz. selection of the research subjects, interviewing procedure and analysing the evidence.

3.5.1 Selection of research subjects

According to Mouton (2002), sampling in social research refers to procedures which produce a representative selection of population elements. For this study a purposeful sample was used, which is very different from random sampling.

Wiersma & Jurs (2005) explain that random sampling is based on the sample being statistically representative of the population, therefore allowing generalisation to the population. The individuals of the population are assumed to be equivalent data sources. However, in purposeful sampling it is based on a source of information-rich cases that are studied in depth. There are no assumptions that all members of the population are equivalent data sources, but those selected are believed to be information-rich cases.

The selection of participants in purposeful sampling is based on prior identified criteria for inclusion (Wiersma & Jurs, 2005). These individuals are selected because the evidence that they can provide is relevant to the research problem. There are many variations of purposeful sampling. Having considered the options, Wiersma & Jurs's (2005) maximum variation sampling offered a suitable strategy for this study. According to them, maximum variation sampling is a strategy by which individuals are selected for the sample because they provide the greatest differences in certain characteristics.

With this in mind, I undertook a purposeful selection of students to be interviewed. The participants had to be selected from a total of approximately 60 first year BEd (GET) student teachers participating in the MIP in 2006. Bearing in mind that the common element amongst the students in the MIP was their poor scores in the mathematics diagnostic test which was conducted at the beginning of the academic year in 2006, I had to seek out a differentiating factor for selection. I decided to select students on the basis of their prior mathematics experience at school level, i.e. the selection included students who had done mathematics up to grade 12 and those who had not. I went about the selection as follows:

i. I examined the university's student database and extracted information regarding students' matriculation results, and divided the MIP students into two lists, viz. students with grade twelve mathematics, and students without.
ii. Next, I examined the MIP student teachers' 2006 *Introduction to Mathematics* (BEd first year) final course results.
iii. Lastly, from each of these ranked lists, I selected two students with the best results, two students with the lowest results, and two students who with the median result (Refer to Table 3.3). In total twelve students were selected.

Table 3.3: Selection of MIP student teachers for interviews in 2007

Students selected according to performance in their first year *Introduction to Mathematics* BEd (GET) course completed in 2006.	**Number of students selected**
Students with grade 12 mathematics	
Highest marks	2
Median mark	2
Lowest mark	2
Total	**6**
Students without Grade 12 mathematics	
Highest marks	2
Median mark	2
Lowest mark	2
Total	**6**

In addition to the twelve students, I also decided to include the MIP lecturer in the study. The primary reason for this was so that I could firstly obtain a better understanding of the methods that were used in the MIP classroom. Secondly, and more importantly, the evidence collected from the MIP lecturer would be used to corroborate evidence collected from students.

3.5.2 Interviewing

According to Kvale (1996: 10-11) “the mode of understanding implied by qualitative research implies alternative conceptions of social knowledge, of meaning, reality and truth…the basic subject matter is no longer objective data to be quantified, but meaningful relations to be interpreted”. Thus, keeping in mind the qualitative thrust of the research design, I opted to conduct interviews to gather the primary evidence, as this was most suitable for the collection of rich evidence of the type that would facilitate the interpretations of *meaningful relations* that Kvale refers to.

There are different types of interviews ranging from highly structured, questionnaire-driven interviews at one pole to open-ended conversational formats on the other (Merriam, 1998). In highly structured interviews, questions and the order of the questions are determined ahead of time. Semi-structured interviews are guided by a list of questions or issues to be explored but the exact wording and order is not pre-determined. Unstructured interviews involved no pre-determined criteria and are essentially exploratory.

For the purpose of this study I decided to implement the standardized semi-structured interview technique. In this type of interview the sequence of usually open-ended questions are determined in advance. The respondents are asked the same basic questions in the same order, which enables consistency (Patton, 1980) (cited in Cohen, Manion & Morrison, 2000).

The strengths of this type of interview according to Patton (1980) are:

- Respondents answer the same questions, thereby increasing comparability of responses;

- A complete set of data for each respondent on the topic addressed in the interview is produced;
- Interviewer bias is reduced through common questions;
- The instrumentation used in the evaluation is available for review; and
- Evidence organisation and analysis is facilitated.

The weakness of this type of interview however, is that there is limited scope for flexibility should the respondent want to broaden their responses. To overcome this I did not institute any constraints or limits to the way the student teachers discussed their experiences in response to the interview questions.

3.5.3 Interview schedule

An interview schedule (refer to Appendix **A**) as well as picture cards (refer to Appendix **B**) were used to conduct the interviews.

3.5.3.1 Formulating interview questions

The interviews were guided by the interview schedule consisting of questions that were divided according to the six components of the activity theory system, i.e. subject, object, community, tools, division of labour and rules. In devising the questions for the interview schedule, I took into account the investigative question of my research. My aim was to draw responses from the interviewees with regards to the components of the AT. In formulating the questions I did not draw attention to the six components but worded my questions in a general sense to probe the six components. The formulation of my questions were guided by the literature review of AT in Chapter Two. The main objective was that the questions associated with the six components should aid in eliciting responses from the respondents that would facilitate my understanding of the activity involved in the student teachers' learning and teaching of mathematics in the MIP.

3.5.3.2 Use of picture cards

For the final question on the interview schedule the interviewees were shown eight picture cards (see Appendix **B**). These cards had to be sorted out ranging from the card that made the most significant impact to those having the least impact on their learning and teaching of mathematics in the MIP. The categories that were outlined in each picture card were: improved results, collaboration, attitude to learn mathematics, confidence to learn mathematics, attitude to teach mathematics, confidence to teach mathematics, and learning of mathematics concepts. The sort card activity was a crucial component as it was related to the student teachers' perception of their learning and teaching of mathematics. The response of the interviewees to this activity would also inform the success of the MIP. I wanted to glean the maximum information from the respondents and thus opted to implement the picture card technique. According to Nurmuliani, Zowghi & Williams (2004) card sorting is a knowledge elicitation method that is used to capture information about different ways of representing domain knowledge. It provides valuable insight into the interviewees' understanding and perceptions on a particular issue. Österåker (2001) states that picture cards allow the interviewees to be more expressive and more verbal thus increasing the amount of information given by the respondent. He further states that the picture cards allow the interviewees to become informants rather than respondents and to tell stories rather than answer structured questions.

3.5.4 Conducting the interview

The interview was conducted using the following guidelines, adapted from Struwig and Stead (2001: 98-99):

- Respondents were allowed to go into more detail on those issues they considered to be important to their success in understanding learning and teaching of mathematics.
- I did not impose my viewpoint on the respondents. Instead I assumed a passive role but probed when I thought a certain issue needed clarity.

The length of the interview was dependant on the depth of response from the research subjects. On average, the substantive discussions in the interview, after preliminary introductions were done, were between twenty to thirty minutes long.

At the start of the interview, I thanked the respondents for being part of the study, offered some introductory remarks and then requested permission to tape-record the interview. In keeping with standard ethical requirements, each interviewee received a signed letter that gave an undertaking that the interview was being conducted in confidence, and that the recording was to be used solely for the purpose of the research (Refer to Appendix **C**).

In addition to the tape-recording, I also made notes while the interview was taking place. According to Babbie and Mouton (2001), notes taken during the interview are important aspects of enhancing the credibility of research undertaken within the qualitative paradigm. The review of both the notes taken during the interviews and as well as actual transcripts of the interviews, served to obtain a more in-depth and accurate understanding of the interactions with the interviewees. For example, a transcript will not show that a student's facial expression was negative when speaking about a particular issue.

Interviews were conducted at the Mowbray Campus of the Faculty of Education and Social Sciences of CPUT. This proved to be a suitable venue, as this was the site of the MIP implementation, and respondents were comfortable being interviewed in an environment in which they were familiar.

The evidence was collected over a period of three months, between March 2007 and May 2007.

3.5.5 Transcribing the interview recordings

According to Cohen, Manion & Morrison (2000) transcribing of interview material for analysis represents the translation from one set of rule systems viz. oral and interpersonal, to another rule system, viz. written language. The prefix *trans-* indicates a change of state or form (Kvale, 1996), and thus transcription implies a type of transformation. Therefore the process of transcribing is a crucial step as there is potential for data loss and distortion.

The transcribing procedures that I undertook, involved three steps to ensure a high quality transcript, so as to minimise distortion and loss of data:

- Firstly, after an initial transcription of the interview, the tape recording and the first version of the transcript were given to a research assistant who listened to the tape and checked for inaccuracies.
- Secondly, before coding the transcripts and interview notes, I listened to the tapes once more, to improve accuracy.
- The third step was applied during the process of coding. It was often necessary to listen to parts of the tape again, especially in instances where I discovered that there was some possible ambiguity in the transcribed text. I also discovered that by listening to the recording during the coding process, I was able to mentally recreate the interview setting. This served to enrich my interpretation of the evidence.

3.5.6 Other sources of evidence

The interview transcripts constituted the main body of primary evidence. In addition to the transcripts I also used two other sources of secondary evidence:

- *Students' written and graphical reflections on their mathematics experiences*

Early in the commencement of the MIP one of the tasks that the student teachers were given was to express their mathematical experiences by written narratives and graphical illustration. Student teachers were free to express any mathematical experiences i.e. prior or present. I felt it was important for me to incorporate the outputs from this task into my evidence especially as this provided an alternative source in respect of the respondents' experiences to mathematics learning. These written and graphical reflections also served as a means to verify the responses given by the interviewees with regards to their perceptions of and attitudes to mathematics learning and attitudes.

- *Test scores*

It was important to examine the student teachers' progress in their mathematical achievements. I examined and compared the test scores of the student teachers' diagnostic tests taken on entering the BEd (GET) course with that of their end of year (2006) Introduction to Mathematics final mark. I felt it was important to identify if there was any shift in the mathematics achievement as this would also inform me about their attitude to the subject. It has been established that students' attitude towards mathematics is positively correlated with mathematics achievements (Masqud & Khalique, 1991). Thus, in my study, I was of the view that the test scores of the student teachers would also provide an indicator of the student teachers' attitude and confidence to learning and teaching mathematics.

As a result, all three sources of evidence were used to answer the research questions (refer Figure 3.2). According to Henning (2004) the use of different sources and approaches to "working the evidence" builds the strength of inquiry, and like the term triangulation, it indicates that by coming from various points or angles towards a measured position you find the true position. In this study, although the interview transcripts formed the substantive body of evidence, my interpretations of this was aided by a broadened understanding of the research subjects gleaned through the test scores and the outputs of the "reflections" exercise.

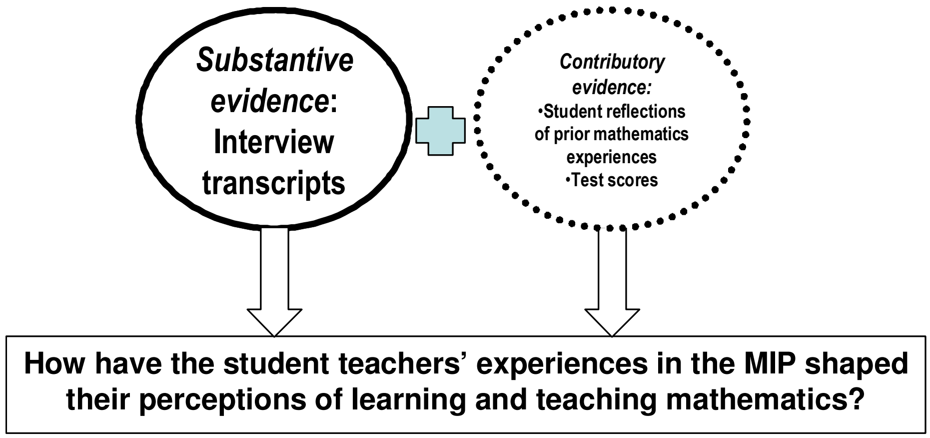

Figure 3.2: Three sources of evidence enhance the strength of the findings

3.5.7 Analysis of evidence

Analysing qualitative evidence is a process that requires analytical craftsmanship and the ability to capture understanding of the data in writing (Henning, 2004).

The method of analysis used in this study was content analysis and Engeström's (1987) Activity theory model assisted in identifying themes within the six components of the activity system.

Content analysis involves identifying, coding, categorising, classifying and labelling the primary patterns in the data (Patton, 2002). Unlike the analysis of quantitative data, for which there are generally agreed rules and statistical formulae, qualitative analysis relies on the researcher's insight and interpretive ability. Lautenbach (2005) suggests that there isn't any single right way of analysing the evidence; however the methods used for analysis should be incorporated according to the purpose of the method and the appropriateness in each case.

Coding entails careful reading of the transcripts, and the assigning of labels to parts of the text that are relevant to the research questions. These labels may be determined by the imagery of meaning they evoke when examined comparatively and in context, or the name may be taken from the words of respondents themselves (Strauss & Corbin, 1998).

The initial stage of coding included line by line analysis of the evidence to ensure a thorough examination of data and that all possible coding categories were identified. This allowed for underlying patterns to emerge. According to Chetty (2007) this type of coding is referred to as substantive codes as the words that the respondents themselves used influenced the labelling of the codes. There were 54 codes that were identified (refer Appendix **D**).

In the second phase of coding, the 54 initial codes were compared with each other and then assigned to broader categories. A category is a group of codes that were linked to each other. The broader categories were then linked to the six components of the activity theory (subject, object, tool, rule, community and division of labour) and were mapped onto Engeström's Activity theory model for further analysis (refer to Figure 3.3).

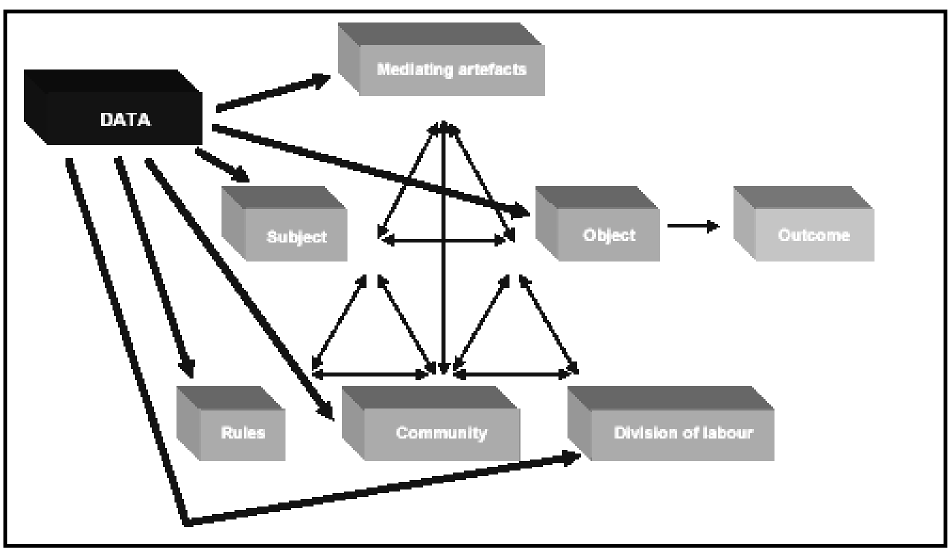

Figure 3.3: **Using Activity Theory as an analytical tool**
(Lautenbach, 2005: 34)

Codes derived from the six components made it manageable to map each individual interview onto Engeström's AT model. Each of the transcripts was condensed, by removing all text that was non-contributory to the codes. Figure 3.4 presents an example of one of the condensed transcripts using the six components of the AT framework. This procedure was followed for all twelve transcripts (refer Appendix **E**) which allowed me to examine each participant as an individual activity system and subsequently all the participants as a collective activity system.

Subject

Influence of prior experience

- My home language is Xhosa, I'm 30 years old, I did maths up to grade 9. Ekwezu. In Eastern Cape.
- The teacher that was teaching me maths in school wasn't very, very serious. If you didn't do you homework he won't do anything. Even if you go outside he won't say anything. When the lecturer was enrolling for me, when she was marking the maths subject I said 'Eish, I must go back home.' Because maths I'm not good at it.
- **Learning Style**: I used to study with my friends. I had two friends who were good at maths so they would help me
- **Language:** No, language didn't have an effect because English is the communication language. There was no way she would use Xhosa. It is a must to understand English and for her using English it was helping me, it boosted my English.
- **MIP Teaching Technique:** Like the use of objects it was good for my understanding
- **Application of teaching tech.:** I can say that practical objects. They helped me, Working together, working in groups

Division of Labour

Lecturer role:

- She was willing to help.
- She played a big role because most of us passed.
- I got somebody who was very, very supportive.
- She was helping me, whenever I need help she would come and help me.

Student teacher perspective:

- like for me the first time I did maths and I see that I must be positive, I must every time practice maths even if there's no homework I must always look at maths and do something even if I wasn't asked to.
- To understand maths.
- I will first try and then if I see that I'm stuck I will ask somebody if it's right or how is it.

Role of Peers:

- I liked group-work because I was gaining the information from the other people.

Peer support

- Sitting in groups was good because if this one didn't understand the concept, she or he is going to help you with his or her own understanding.
- For the first time I ask the person who is nearby me and if she doesn't know we would ask the lecturer?

Tools

Lecturer role:

- She used to use the techniques that you can see. Like if she was teaching the shapes she will tell you to look at that thing.
- She would make sure that you have the picture of what she is talking about.

MIP instruction mode

- It's a net then she 'would say cut this and make something out of it'.
- Worksheets and the overhead.
- For me it was good because it was the first time I came across that kind of thing because we used to write on the board so it was a new thing to me.
- It worked because even if it was not a board that she can leave the information for long on the OHP. You can stop her and ask her what does that mean, she wouldn't mind.
- The worksheets were okay because we could take them home and practice if you don't understand and ask somebody to help you if you don't understand.

Slow pace

- It was a slow pace. It was easy for us to grasp.
- Yes and she make sure that we did understand the maths.

Small class size

- The small class size improved my learning because we were few and if this group doesn't understand you were allowed to go and ask if you see that she's busy with the other group.

Community

Peer group benefit:

- Sitting in groups was good because if this one didn't understand the concept, she or he is going to help you with his or her own understanding.
- They enjoyed participating in class.

Lecturer role:

- Very comfortable, Yes I was. I can say maths classes was the one that even now I'm more comfortable. I don't know whether it's with Esme or what. Because most of the time if I don't understand I will shout 'Esme, Esme come and help me.' She knows.

Figure 3.4: An example of a condensed transcript, post content analysis, organised according to the six components of Engeström's Activity Theory model

/contd…

Object	Rules
Improve grades • It has improved my marks. Last year I was always getting less than 60 % but this year we wrote the test and I got 68 **Motivation to learn** • Everyday I'm getting homework for maths when I come home it's the first thing I do even if it's not for tomorrow it is for next week, it is the first thing I do. I've told myself to do it. • If we are doing class work or homework if I've used my own steps and Esme has used her own steps I will tell her 'Esme I did it like this, but my answer is the same like yours.' And she would say 'even this steps that you used are right.' **Collaboration** • You know my group can solve some answers for me, then can say 'how do you say this' and I will come with different answer maybe it's the right answer. They can rely on me. **Confidence to teach** I don't have confidence in teaching maths. I'm not sure. You know when you teach you must expect some questions so you must be able to answer those questions and people will come up with different questions and need different answers, so you must be prepared. I think I need the confident first. **Overall impression MIP** • I didn't feel bad in the MIP and I realised that now I'm going to work hard so as to fit into this group because that is where I belong. • No my learning style hasn't changed • Everyday I'm getting homework for maths when I come home it's the first thing I do even if it's not for tomorrow it is for next week, it is the first thing I do. I've told myself to do it. • I can say last year there was a lot of information that I can implement this year. Last week we were doing geometry and we also did geometry last year and I had homework and I went to the worksheets from last year and saw how we did that	**Structure of lesson** • Most of the time it was group work. • There were times that we were given worksheets so that we can work individual and there were times that we would work with a partner or in a group. • Practical work we used to do that as a group. **Time** • It was good. [the time allocated for the lectures was sufficient to meet the expectations of the course] **Curriculum** • I can say they were alright because we managed to finish for the whole year. • They were good because last year we did patterns and even at school where I was, I was given the same topic. **Assessments** • The spot tests and the exams. I can say the spot test it helped me because in each and every chapter that we finished we got a spot test. So it was then that I realized that. **Implicit** • Here was no rules, but because we were all grown up it was like everybody want to understand. There was no-one that was making a noise. Everybody was listening to the teacher.

Figure 3.4 (contd.): An example of a condensed transcript, post content analysis, organised according to the six components of Engeström's Activity Theory model

This populated system was then used to examine how the process of learning and teaching mathematics in the MIP could be interpreted as an activity system. The components of the activity theory model assisted to understand the emerging personal experiences of the learning and teaching of mathematics by the student teachers and how the programme had shaped their perceptions of mathematics. It also assisted to illuminate social aspects of learning and teaching mathematics within the MIP classroom environment.

3.5.8 Reporting of findings

According to Kvale (1996), reporting is not simply re-presenting the views of the interviewees, accompanied by the researcher's viewpoints in the form of interpretations. Reporting on research is itself a social construction in which the author's choice of writing style and literary devices provide a specific view on the subjects' lived world.

In order to explore the student teachers' experiences with regards to learning and teaching mathematics in the MI classroom, the AT model consequently also provided a useful framework to report on the findings. The AT model was adapted to the context of this study, and the findings are reported on using the adapted AT model as a frame.

3.5.8.1 Use of activity theory (AT) to discuss the findings

According to (Engeström, 1987) AT is used to situate an activity within a particular socio-cultural context and is used to analyse both individual and collective activity. Furthermore AT provides the means for organising knowledge about an activity system. Thus AT was used in this study as both a theoretical framework, and as a 'tool' to facilitate the analysis process. Thus the discussion of the findings is presented within an AT framework according to its six principal components (refer to Figure 3.5).

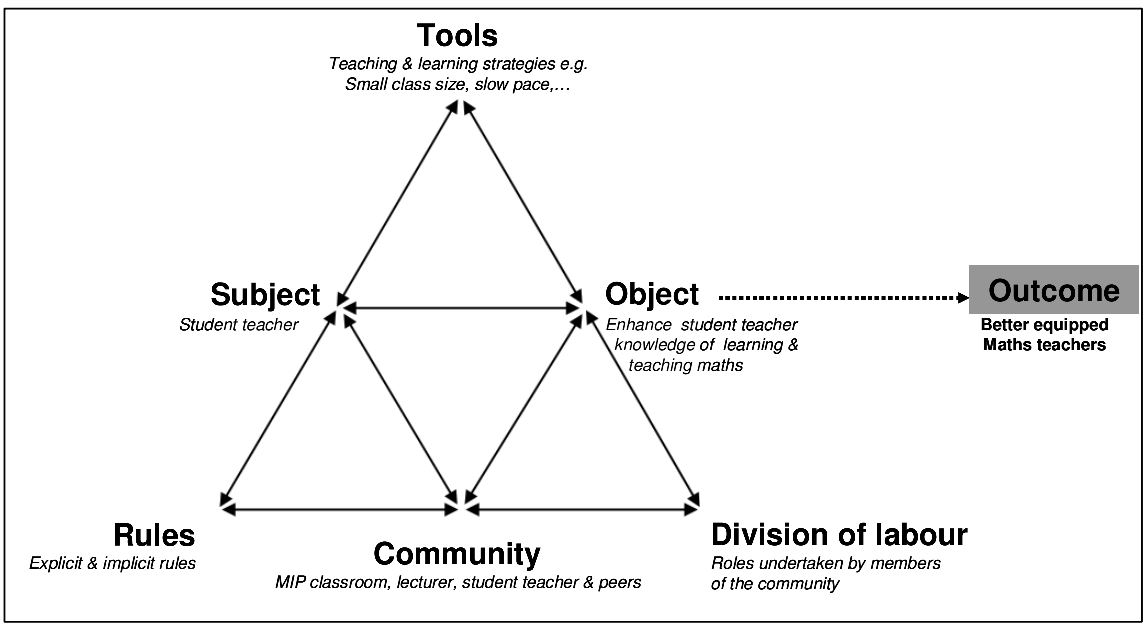

Figure 3.5: Engeström's Activity System as applied to this study

The findings of the relationship and inter-relationships linked to the six components of Engestrom's Activity system, is fully discussed in Chapter Four.

3.5.9 Use of qualitative software package

For the development, support and management of the qualitative analysis, the QSR Nvivo computer assisted, qualitative data analysis software (CAQDAS) package was used. CAQDAS are designed not to undertake the analysis for the researcher, but rather to facilitate the process. Furthermore, it frees the researcher from the drudgery of using the manual methods of coding, comparing and categorizing. The researcher is free to focus on the acts of reflecting on the data and identifying and relating concepts pertaining to the study.

QSR Nvivo functions as a tool kit for the researcher. The following capabilities have been extracted from the software user guide:

- It provides a range of tools for handling rich data records and information about them, for browsing and enriching text, coding it visually or at categories, annotating and gaining access to records.
- It has tools for recording and linking ideas and for searching and exploring data. It helps in connecting parts of the project. As you link, code, shape and model data, the software helps you manage and synthesize your ideas.
  (QSR International, 2002)

3.6 Verifying the quality of the study

The case study approach has received much criticism regarding the possible lack of accuracy and generalisability as compared to quantitative methods (Bessoondyal, 2005).

According to Lincoln and Guba (1985), trustworthiness is an important aspect of qualitative research; it is equivalent to the concepts reliability and validity. Reliability is generally understood to concern the replicability of research and the obtaining of similar findings if another study using the same methods was undertaken (Lewis & Ritchie, 2003). Validity according to McMillan & Schumacher (2001) refers to the degree to which the interpretations and concepts have mutual meanings between the participant and the researcher. According to Lincoln and Guba (1985) there is no validity without reliability and therefore no credibility without dependability. They further state that a demonstration of validity in research is sufficient to establish the reliability of that research. Therefore according to Lewis & Ritchie (2003), in discussing reliability and validity, qualitative researchers are interested in the confirmability of findings, which can be assessed through examining credibility, transferability and dependability.

Credibility, according to Babbie & Mouton (2001: 277), refers to "the compatibility between the constructed realities that exist in the minds of the respondents and those that are attributed to them". They suggest that referential adequacy (relates to being able to prove the existence of the evidence that has been collected) and member checks (this involves going back to the informants to verify the researcher's interpretation of the evidence) are strategies that will enhance the credibility and authenticity of qualitative research. Another technique, according to Lincoln and Guba (1985) that addresses credibility includes making segments of the raw data available for others to analyse.

Transferability refers to the extent to which the research findings can be applied in other contexts or with other respondents. Thick description and purposive selection of informants are two strategies that have been proposed by Babbie & Mouton (2001).

Dependability and confirmability according to Lincoln and Guba (1985) can be established making use of an audit trail. Remenyi *et al.* (1998:116) describes two ways in which this can be achieved:

- By keeping the evidence collected in an easily retrievable form, to enable others to investigate it should doubts regarding the research ever be raised.
- The researcher should keep a log cataloguing research design decisions and justifications for these.

Based on the above discussions, Table 3.4 below outlines a framework for enhancing the trustworthiness of this study.

Table 3.4: Strategies used to enhance the quality of the research outcomes of this study

Credibility	• In-depth individual interviews, • Verbatim accounts of interviews, • Direct quotations of participants are used to illustrate participants' meanings • Referential adequacy: Audio recording evidence • Member checks: Confirming evidence with participants
Transferability	• Participants selected purposefully to maximise the range of specific information for the research.
Dependability	• Audit trail: to facilitate an external audit to establish levels of dependability and confirmability of study. Audit trail included audio-tapes of interview, transcripts of interview, hard copy of all documents coded by qualitative software package.

3.7 Ethical issues

The inclusion and consideration of ethical issues presently has greater emphasis in qualitative educational research than previously. Social scientists, in their search for knowledge and the quest for truth, have a responsibility not only to their profession but also to participants they depend on for their work. Caven, (1977) (cited in Cohen, Manion & Morrison, 2000: 56) define ethics as a matter of principled sensitivity to the rights of others. Being ethical limits the choices we can make in the pursuit of truth. Ethical codes prescribe that while truth is good, respect for human dignity is better, even if in the extreme case, the respect of human nature leaves one ignorant of human nature.

In this research study the following ethical guidelines, primarily related to ensuring that the rights of the research subjects to confidentiality, were followed:

- Written and verbal consent of the interviewees.
- Written and verbal consent of the interviewees being audio-taped.

- Participants informed of the purpose of the study.
- Participants were assured of anonymity and confidentiality.
- The participants, for verification, reviewed interview transcripts.
- Participants informed that the information obtained would be used for exclusively for research purposes.

3.8 Conclusion

In this chapter, the methodology and research design that was adopted has been discussed in great detail. The different phases of the study were described in a logical sequence. This included a description of the design of the research instrument, and the use of multiple data sources. Lastly the ethical considerations that were taken throughout this study were detailed.

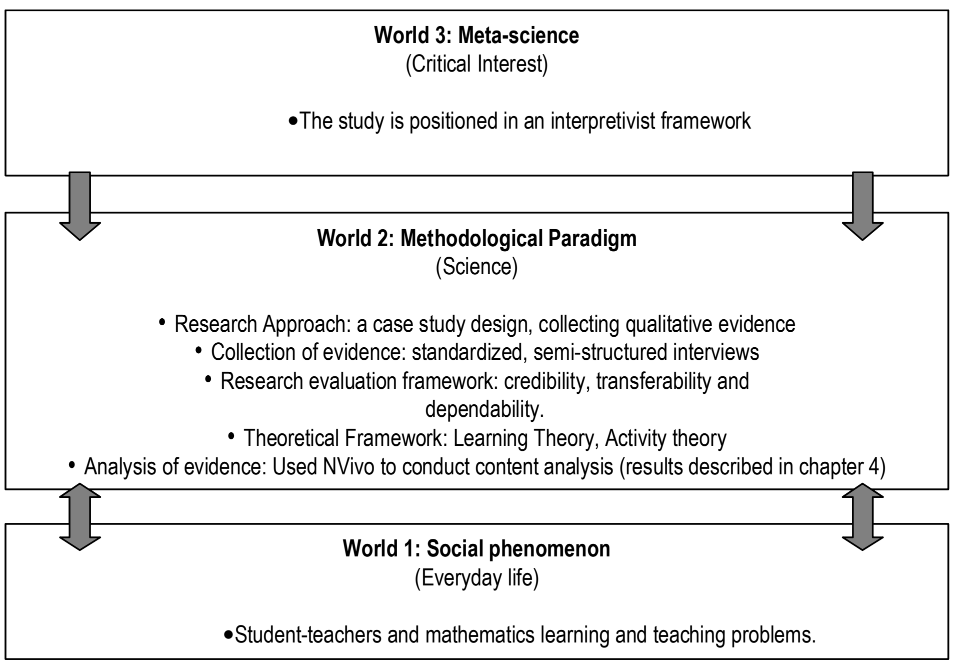

Figure 3.6: The three world framework as applied to this study

In conclusion, the following three-world framework (Figure 3.6), adapted from Babbie & Mouton (2001:48), is used to serve as a summary of my research design and methods. The following chapter which presents the outcomes of the execution of these methods discusses the findings of the study.

Chapter Four

Research findings

4.1 Introduction

The main objective of this chapter is to present the findings in response to the principal research question: *How has the Mathematics Intervention Programme at CPUT shaped student teachers' perceptions of learning and teaching mathematics?*

In Chapter Two, the prominence of activity theory (AT) in the literature in respect of similar studies was highlighted. Subsequently, in Chapter Three I motivated that AT was a suitable theoretical frame for this study. Thus in this chapter the findings is presented within an activity theory framework. The chapter is organised as follows:

- Firstly, a brief overview of the use of AT as a framework is presented;
- Secondly, the findings are presented in terms of each of the following components of AT, viz.:
    - **Subject**, i.e. the student teacher;
    - **Community**, i.e. the classroom, peers of the subject, and the lecturer;
    - **Rules**, i.e. implicit and explicit;
    - **Division of labour**, i.e. the lecturer, student teacher and peers;
    - **Tools**, i.e. teaching and learning strategies used in the MIP classroom; and
    - **Object**, i.e. enhance knowledge of teaching and learning mathematics.
- Thirdly, the findings are plotted onto the AT model. This provides a platform for a juxtaposition of these components. Thus the subsequent chapter discusses the relationship between the components within the activity and how these have influenced

the student teachers' perceptions of learning and teaching mathematics in the MIP.

For the purpose of this study the activity was defined as student teachers' learning and teaching of mathematics within the MIP learning environment. The upper part of the triangle in Figure 4.1 (subject, object and mediated tools) was used to examine how the student teacher used the mediated tools to scaffold and build on their own understanding of learning and teaching of mathematics. The lower half of the triangle (rules, community and division of labour) was used to examine how the social environment within the MIP classroom influenced the student teachers' perceptions of learning and teaching mathematics.

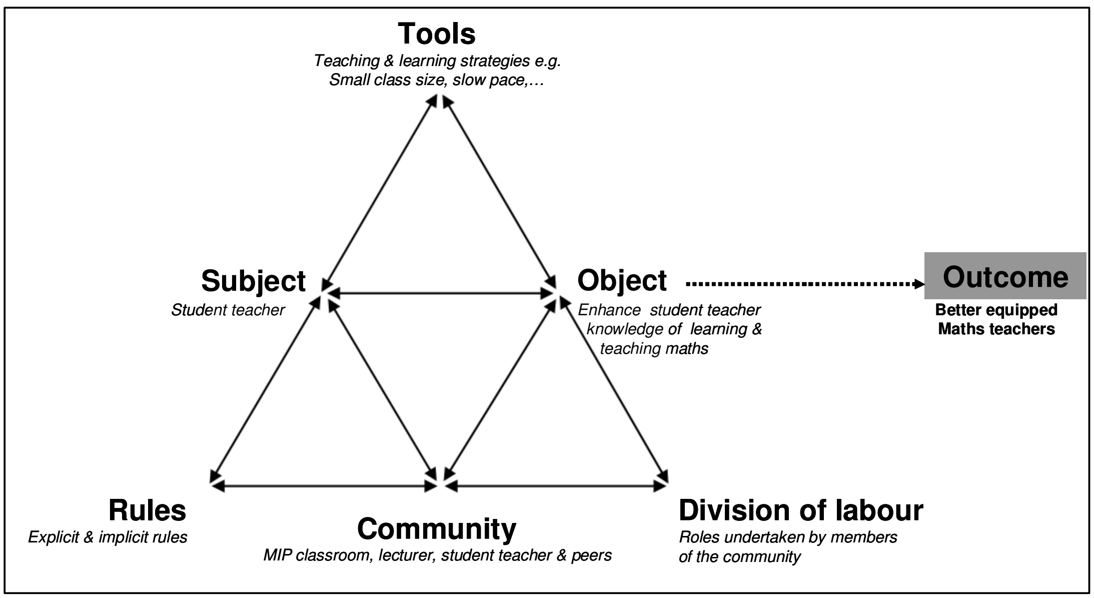

Figure 4.1: Engeström's Activity System as applied to this study

Activity theory thus facilitated a holistic interrogation of the student teachers' learning and teaching of mathematics within a particular social setting, viz. the MIP classroom. In addition, and more importantly, it magnified each component to be examined individually and with equal attention. Hence AT enabled me to explore the relationships between the six components of the AT system as they pertained to the research problem.

4.2 Activity theory perspectives of mathematics learning and teaching

The findings of each of the six components are reported on individually.

4.2.1 Subject: the student teacher

The subject, from an AT perspective refers to the individual or group of actors engaged in a particular activity (Engeström, 1987). The subject of the activity in this study was the student teachers in the MIP. The student teachers selected for the MIP were students who had been identified as at risk of failing the first year mathematics course in the BEd programme. Table 4.1 provides demographic information about each student selected for this study. The last column of the table provides excerpts from the interviews with the subjects that typify their prior school-based mathematical learning experiences.

Table 4.1: Demographics of respondents showing previous mathematics experience

Student teacher[1]	Age	Highest mathematics qualification	First Language	Excerpt from interview indicating student teachers' prior mathematical learning experiences
Ntobi	40	Grade 9	Xhosa	"*Had a bad maths teacher in school. Scared of failing maths in grade 12 therefore did not take it beyond grade 9*".
Thabi	30	Grade 9	Xhosa	*"Did not have a teacher that was serious about maths. He never checked homework or attendance".*
Olive	29	Grade 9	Afrikaans	*"Was afraid of doing maths. Sat in the back of the class so that I would not be noticed".*
Morgan	22	Grade 9	English	*"Was in a religious school. Was taught to memorize work".*
Mandy	20	Grade 9	English	*"I was scared of doing mathematics, I did not know how to do it".*

[1] Note that in keeping with confidentiality agreements with the research subjects, actual names have been replaced with pseudonyms throughout the dissertation and in the relevant appendices.

Student teacher[1]	Age	Highest mathematics qualification	First Language	Excerpt from interview indicating student teachers' prior mathematical learning experiences
Sandy	19	Grade 9	English	*"Did not have a good maths teacher at school. Teacher was not creative in the lesson".*
Vosi	29	Grade 12 (SG)	Xhosa	*"Not confidence in maths. Failed grade 12 maths due to lack of confidence and working on my own".*
Fran	25	Grade 12 (SG)	English	*"Maths teacher was very good but could not teach the subject well. We mainly used the text book and worked out examples".*
Nora	24	Grade 12 (SG)	Xhosa	*"The teacher taught maths in the traditional way, we had to work on our own".*
Jane	22	Grade 12(SG)	Afrikaans	*"Had a very advanced maths teacher, scared me, I developed maths anxiety and therefore did badly in my maths exams".*
Xhosi	21	Grade 12 (SG)	Xhosa	*"Had a very knowledgeable maths teacher at school but she was unable to teach maths effectively".*
Mira	20	Grade 12 (SG)	English	*"My maths teacher was the Deputy Principle he was rarely in class. Did not spend time with individual students as higher and standard grade students were taught together".*

The above table provides an important background to the subject. There are several significant observations that can be made from Table 4.1. Firstly, the ages of the subjects ranged from 19 years to 40 years. Sixty seven percent of the student teachers in the study were students who returned to the university after an extended period of absence. This meant that many of them were not familiar with the OBE approach to learning mathematics. Secondly, the majority of the subjects did not have the basic mathematical grounding needed for the B Ed first year mathematics course. Seventy five percent of the student teachers' prior exposure to mathematics ranged from 4 years to 15 years before entering the B Ed programme. One of the interviewee's comments typifies the nature of their school-based experience with mathematics:

> *"I finished school in 1992, I last did maths when I was in standard 7. I dropped maths when I was in standard 8 because I met a teacher who didn't explain maths properly and I was losing marks"* (Ntobi, 2007).

Thirdly, from the above table it is noted that 58% of the student teachers were not English first language students. All the student teachers were questioned about the impact of learning mathematics through the medium of English in the MIP. All the student teachers indicated that the medium of instruction was not a debilitative factor to their learning of mathematics. Varying reasons were given by the following respondents with regards to the language of instruction and its impact on their learning of mathematics in the MIP. For example the following respondent comments on her observation of the impact of being taught in English to her MIP peers:

> *"My first language is English, language was not a problem for me. The MIP lecturer did speak slower though than the other lecturer. She was very good at that, because she would speak slower and she would make sure that everybody understood the words that was coming out of her mouth because there were third language English students in the class that wouldn't understand and because some of them hadn't learnt in English before, the concepts were a bit difficult to understand in English, so she would explain it in different ways so that they can understand"* (Fran, 2007).

Two of the Afrikaans first language student teachers had the following to say with regards to being taught in English:

> *"It was not so a big issue. With the MIP lecturer if I don't understand something in English then I can ask her in Afrikaans and she will explain it into Afrikaans, so the language was fine, I understand it"* (Jane, 2007).

> *"No, not actually. At first I was very scared of the English because I had to learn in English now but the MIP lecturer is Afrikaans speaking as well so if I didn't understand the question, I would ask her it in Afrikaans then I would understand"* (Olive, 2007).

Two of the Xhosa speaking student teachers made the following remarks:

> *"As I said, English is my second language so I didn't have that much problem in her language because I understood what she was saying. If I don't understand I just asked. The language was good for me, she was slow and it was okay"* (Nora, 2007).

The other respondent adds:

> *"No, it didn't have an effect because English is the communication language. It is a must to understand English and for her using English it was helping me, it boosted my English"* (Thabi, 2007).

These sentiments were also felt by the other Xhosa first language student teachers interviewed. The aforementioned is a reflection of the perceptions of the at risk student teachers in that language was not really a barrier to their learning of mathematics.

The final significant observation with regards to the student teachers as subjects is evident in Table 4.1, column five. The results reveal that majority of the student teachers who were interviewed had entered the MIP with a negative attitude and a fear of learning mathematics as a result of their previous experiences in the schooling system.

The foregoing provides a synopsis of the background of the at risk student teachers in the MIP. This background is essential as it provides a backdrop of the subjects' experiences and their particular needs in the learning environment of the MIP. Issues relating to the diversity of their ages; weak foundations in mathematics; long period of absence from formal mathematics learning and negative attitudes and anxiety towards the subject were important considerations in analyzing and understanding how the subject used the mediated tools in the MIP environment to achieve the object. The discussions of the findings that follow therefore take into account this profile of the subject.

4.2.2 The tools

The tools refer to any physical, mental or material tool that could be used in an activity to transform the object. In this study the teaching and learning strategies used in the MIP are regarded as the mediating tools to enhance the student teachers' knowledge of learning and teaching mathematics. A variety of examples from the lecturer and student teachers' interviews are used in this section to illustrate the effect that the mediating tools have had on the student teachers' learning and teaching of mathematics. The lecturer's interview highlighted the different teaching and learning strategies that were used as mediating tools in the MIP whilst the student teacher's interviews were used to gain insight into their perceptions on the mediated tools utilized and the effectiveness of these tools to their own learning and teaching of mathematics.

4.2.2.1 Teaching and learning tools used by the MIP lecturer

A wide variety of teaching and learning strategies were used by the lecturer as mediating tools to improve the student teachers' performance.

Table 4.2 provides a list of the strategies that emerged through the analysis and also describes how it was applied in the mathematics lessons in the MIP.

A teaching strategy that formed an integral part of the MIP was the slower pace in which the mathematics lessons were conducted. Time was provided after each activity for the lecturer to provide feedback and for student teachers to ask questions or enquire about any aspect of the lesson that they did not understand. The lecturer did not hesitate to re-teach sections that student teachers had problems understanding.

Table 4.2: Teaching and learning strategies identified and applied to the MIP class

Teaching and learning strategies	Method of application
Group work	Collaboration, discussions, expressing opinions, reflections.
Modelling	Demonstrating, using sequenced steps technique, explaining specific mathematical skills.
Scaffolding	Peer tutoring, group work, a wide range of real life examples, breaking up steps, homework, re-explaining/demonstrating concepts/skills.
Coaching	Walking around the class & assisting groups and individuals, encouraging & motivating students, peer tutoring, group work, students reflecting on work done.
Promoting student responsiveness	Questioning, discussions, reflecting, expressing opinions, group work, peer tutoring.
Homework	Given daily and corrected in the follow up lesson.
Worksheets	Variety of worksheets: interactive, testing basic skills, developing concepts, problem solving
Use of Objects	Used to introduce lesson, explain concepts e.g. shapes, number concepts, nets, and tessellation. Students also build or bring objects.
Spot Tests	At the end of each session after a new concept has been completed.
Slower pace of work	Feedback at the end of each session taught, allowed questions, re-teaching, repetition of basic mathematical skills, plenty of application worksheets, lecturer walked around class assisting groups and individuals.
Small class size	MIP class size was kept to a maximum of 12 student teachers.
Other resources	Overhead projector, charts, newspaper articles, chalkboard.

The strategies shown in Table 4.2 indicate that there was no standardized teaching or learning model that was adopted in the MIP. However all of these teaching strategies are a subset of the various theoretical teaching perspectives discussed in Chapter Two. For example modelling, scaffolding and coaching are associated with cognitive apprenticeship instructional model; group work, small class size and promoting student responsiveness belong to collaborative learning; however interacting within the ZPD, either with the lecturer or more capable peer, to achieve a better understanding of mathematical tasks could be done by scaffolding the students learning by using any of the teaching and learning strategies referred to in Table 4.2.

Thus the different teaching and learning strategies used were adopted specifically for the needs of the student teachers in the MIP class. The strategies utilized were intended to achieve the following: reduce mathematics anxiety, build confidence, and improve performance and understanding of learning and teaching mathematics. The various techniques used in the MIP had allowed the student teachers to complete tasks with minimum effort, i.e. reduced frustration or anxiety and reach levels of performance that they had previously felt was unachievable. The following is an example of an interview excerpt that substantiated the above finding:

> *"The lecturer always used different methods, she will explain something to you then she will use the board and put some examples, etc and you must work it out. Then she will walk around and if you have a problem you can ask her. She's a person who will help you. You just raise your hand and she will be there. This style of teaching really improved my marks. I didn't want to teach maths because of my anxiety but now I want to teach maths, I understand it"* (Olive, 2007).

According to Bannon (1997) tools shape the way human beings interact with reality; shaping external activity ultimately results in shaping internal activity. It is therefore helpful to regard the teaching and learning tools as an external activity which ultimately shapes the internal activity, i.e. the student teachers' understanding of mathematics. Bannon (1997) also states that there is a mutual transformation between external and internal activities and that one cannot be understood in isolation from the other. In this study the mutual transformation will not only allow the student teachers to understand mathematics more meaningfully but to also apply the knowledge gained in practice as a mathematics teacher.

4.2.2.2 Student teachers' perception of learning and teaching tools

The objectives of the MIP were twofold. In the first instance, the MIP was directed at improving the subject's ability to learn mathematics and thereby increasing mathematical knowledge and skills. Secondly, the MIP was aimed at nurturing and improving the subjects' capacity to teach mathematics. Therefore this section reports on how the teaching and learning strategies used in the MIP influenced the subjects' knowledge of teaching strategies.

Table 4.3: **Teaching & Learning Strategies identified by the students**

Teaching & Learning (T & L) strategies identified by the student teachers	Ntobi	Sandy	Olive	Vusi	Xhosi	Thabi	Morgan	Nora	Mira	Fran	Jane	Mandy
Worksheets	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
Homework	✓			✓					✓		✓	
Board work	✓	✓					✓	✓			✓	
Use/making of objects		✓	✓	✓	✓	✓		✓	✓	✓		✓
Overhead projector		✓	✓			✓	✓		✓			
Group work	✓	✓	✓			✓	✓		✓	✓		✓
Question & answer				✓			✓					
Plenty of examples & repetition	✓	✓	✓	✓	✓				✓	✓	✓	
Small class size	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Slower pace of work		✓	✓		✓	✓	✓	✓		✓	✓	

Key

✓	Identified effective T & L strategies

Table 4.3 highlights teaching and learning strategies used in the MIP that were identified by the subjects. What emerged from the analysis was that some strategies that were used by the lecturer were not identified as alearning or teaching strategy by the subjects. The analysis of the interviews suggests that learning and teaching strategies that the subjects were familiar with were not perceived as mediated tools for learning and teaching. For example, from Table 4.3 it was noted that very few of the student teachers identified homework, board work, the use of the

overhead projector and questions and answer techniques as teaching and learning tools. However strategies that were new to the student teachers or had an impact on their learning and teaching of mathematics were perceived as mediated tools for learning and teaching. For example, the following strategies, illustrated in Table 4.3 influenced the student teachers' learning and teaching of mathematics; use of worksheets, use/ making of objects, group work, plenty of examples and repetition. One of the respondents interviewed had the following remark to make with regards to teaching and learning techniques:

> *"The MIP lecturer will first let the learners solve the problem and then ask them how they came to that answer. She will mention that there are different ways to get the answer she would use different ways to teach us for example, worksheets or when she introduced shapes she gave us papers and asked us to do some shapes. There were a lot of interaction and real-life examples that were being used in the class activities"* (Sandy, 2007).

A strategy that appeared to be very successful was the small class size (see Table 4.3). All the student teachers interviewed acknowledged that the small class size was effective in their learning and teaching of mathematics. As Gillies (2002) stated that students benefit academically and socially from small group learning. Gillies (2006) study revealed that students' and teachers' verbal behaviour in small groups was more caring, spontaneous, personal and positive as the teacher and students worked more closely. The following two extracts corroborate the effectiveness of small class size to learning and teaching mathematics in a context such as this one:

> *"In the small class, she had time to go around and when someone was stuck so she would attend to that. Also everyone gets a chance to give an opinion or an answer so we built a lot of self-confidence in the class. I liked the environment, the small classes and the attention"* (Xolisa, 2007).

In another interview the respondent adds:

> *"I felt good because someone would actually listen to me when I had a problem. Class was nice and small and so if I want to ask something I felt free to ask that"* (Thabi, 2007).

In addition to the small class size was the slower pace in which the lecturer had set out her planned lessons. From Table 4.3 it is evident that there were mixed reactions to the pace of the planned lesson in the MIP class; 66% of the student teachers appreciated the relaxed pace in which the lessons were conducted and regarded this as beneficial to their own learning. Out of the 34% that did not particularly approve the slower pace of work, 17% of the subjects used this time to their benefit. They utilized the time available to teach their peers who were struggling and also to work out additional examples. This advanced the student teachers' own teaching and learning of mathematics. For example, one of the respondents had the following to say with regards to the pace of work:

> *"Because I was used to the fast pace[2] I caught on a little quicker than some of the other student;, so at times I would help the students that needed help, it made me feel good; I like teaching them and it also gave me more revision time; so it was in my favour"* (Mandy, 2007).

On the other hand there were exceptions regarding the value of the slower pace environment. The remaining 17% pointed out that they were bored, a remark from one of the respondents in her interview revealed that the slower pace of work bored her and at times she was tempted not to attend the MIP class. This underscores the importance of the learning environment being individualised.

4.2.2.3 Correlating MIP teaching and learning strategies with practice teaching application

Table 4.4 shows that the most effective teaching and learning strategies that the student teachers acknowledged were: the use of objects (75%), repetition of work done and utilization of a wide range of examples (17%), and the question and answer technique (8%). The use of objects as a teaching strategy brought about a visual understanding of the relevant mathematical concepts. As one respondent comments:

> *"So if we do nets she gave us a box and then we had to open the box and then draw the lines around the box and then she would say now that is a net. In Geometry we would make the shapes that we were going to use to help us do our maths work. The actual making of the objects was good because if you do it you won't easily forget it"* (Vosi, 2007).

The subjects were able to see the benefits of selecting this technique to enhance their own learning of mathematical concepts.

[2] Mandy had switched from the mainstream mathematics class to join the MIP class.

Table 4.4 also indicates that the teaching and learning strategies that were identified to be most effective to the subjects' own understanding of mathematics were also utilized when they taught a mathematics lesson during teaching practice. From the analyses it emerged that many of the subjects mirrored their MIP lecturer's techniques of teaching mathematics.

Table 4.4: Correlation between most effective teaching and learning strategies identified by the student teacher and the strategy/ies used during practice teaching.

Most effective Teaching & Learning Strategies identified by student teachers	Ntobi	Sandy	Olive	Vusi	Xhosi	Thabi	Morgan	Nora	Mira	Fran	Jane	Mandy
Worksheets												
Homework												
Board work												
Use of objects	✓ TP	✓ TP	✓ TP	✓ TP	✓ TP	✓ TP		✓ TP			✓ TP	✓ TP
Overhead projector												
Group work						TP						TP
Question & Answer				TP			✓ TP					
Examples & repetition				TP					✓ TP	✓ TP	✓ TP	
Small class size												
Slower pace of work												

Key

✓	Most effective T & L strategy
TP	Strategy used during teaching practice

This is confirmed with Schoenfeld's (1983) statement, that when teachers explicitly demonstrate and explain specific skills and strategies, students have a better sense of how to approach the task. As a result it is not unusual that the student teachers would want to demonstrate these skills in their own teaching. The following quotes corroborate the fact that students felt comfortable modelling their lecturer's learning and teaching strategies:

> *"You know, I was teaching maths when we were at teaching practice and I really enjoyed myself because I actually applied the same technique that the MIP lecturer was doing without even knowing because I wasn't only teaching a sum on the board, but I will always ask and I see it worked. I always ask the learners 'what do you think?' and I put them in groups and stuff so it helped me, I applied that and*

> *that works for me. Asking questions, 'do you understand, what don't you understand, it was good"* (Morgan, 2007).

Another respondent added:

> *"I used the same techniques as the MIP lecturer was using. First let the learners solve the problem and ask them how did they come to that answer and then afterwards I will say how I come to the answer, because there are different ways to get the answer; the lesson went well I enjoyed it and the students understood it"* (Olive, 2007).

This was an important observation, since it is indicative of the transference of the learning in the MIP into the external school environment.

4.2.3 The community

The community in this study comprised the MIP classroom, peers, lecturer and the student teacher. This section focuses on the community and discusses the activity of the student teacher within the social context of the environment in which the subject operated.

4.2.3.1 The classroom

- *Layout*

The layout of the MIP classroom was different from the traditional classrooms. Desks and chairs were arranged in groups. This created adequate space for movement in the classroom. Such planning not only allowed the student teachers to interact with their peers and work in groups or individually but also enabled the lecturer to interact with the class in small groups or on a one-to-one basis, with greater ease and success. This physical arrangement is supported by Schiefele & Csikszentmihalyi (1995), who argued that a flexible and appealing classroom environment is important as it can influence student motivation and enthusiasm when faced with challenging mathematical tasks. The arrangement of the MIP classroom was flexible in that allowance was made for the desks and chairs to be moved around to accommodate varying group sizes and individual work. This flexibility in the physical arrangement had a positive influence on the subjects, e.g. one student indicated that

> *"The lecturer made us feel comfortable; we could sit anywhere we wanted to sit as long as we're comfortable and can see her properly"* (Vosi, 2007).

- *Relaxed and safe environment*

The MIP classroom had a relaxed atmosphere. The ambience enabled greater interaction between students and lecturer. The lecturer was therefore able to provide individualised tuition thereby encouraging students to use a diverse range of methods to solve problems. This was corroborated by one of the interviewees:

> *"The lecturer had time to go around and check on groups, when someone was stuck she would attend to them. I liked the environment in the MIP classroom, the small classes and the attention"* (Xhosi, 2007).

The student teachers acknowledged that they felt safer in the MIP classroom as compared to their other lecture venues. This security encouraged them and offered better scope to explore innovations and undertake a trial of a wider range of strategies when responding to mathematical problems. The student teachers felt that their work and comments in the MIP classroom were valued, respected and accepted by the lecturer and their peers. They found the MIP classroom to be a non-judgmental environment which allowed and encouraged them to take risks without the fear of being 'laughed at', or becoming despondent with comments such as 'wrong' or 'stupid'. The classroom ambience that facilitated the student teacher feeling at ease is highlighted in the following interview excerpts:

> *"The MIP class was informal yet the lecturer wouldn't let it go out of hand. It was fairly maths based. There wasn't really a lack of participation in the class. I think that everyone felt confident enough to participate; I think that people understood that in this class we're not here because we're brighter that anyone or that we're dumber than anyone else. There was no such thing as a stupid question because if you didn't understand you knew that you could just ask and the lecturer would go through it or someone would go through it with you. So students participated, there was no problem"* Fran (2007).

Another respondent added:

> *"As we were a smaller group and no one looked down on you, so it's easy to say you don't understand and the lecturer will help you. We were all very interactive and confident. We weren't shy or scared to make a mistake. If we made a mistake we would all correct it"* Mira (2007).

The responses of the subjects during the interviews indicated that the physical space i.e. the arrangement of the classroom furniture and the creation of a relaxed and safe environment were contributory to the reduction of their mathematics anxieties and increasing their willingness to explore diverse approaches when solving problems.

4.2.3.2 Peers in the MIP classroom

The peers of the subjects had an important role in that they facilitated the social interaction in the community. The student teachers were involved in activities that concerned exploring, co-operating, sharing and reflecting with their peers. Working with peers brought about a sense of security, self confidence and a reduction in anxiety for many of the student teachers. This is demonstrated in the following remark by a respondent who speaks of the 'enjoyment' that he obtained from the peer group interaction:

> *"I think they enjoyed it to be honest. Yes all of us enjoyed it. There was interaction between us you know like I said we could learn from each other and stuff like that. If you know something you can tell me and we can help each other"* Morgan (2007).

The cooperative working environment in the MIP also allowed the student teachers to take on roles such as observer, teacher, facilitator, etc. A respondent commented on group work as follows:

> *"Group work was fine because the people in the group we understand each other and we work well together and we have learnt a lot about someone's interpretation or someone's answer to a question, it's not the same as yours, so you get a broader understanding"* (Olive, 2007).

The lecturer encouraged the student teachers to decide amongst themselves, either as a group or individually, as to how they would solve a given mathematical problem using their own methods and understanding to arrive at an answer. Many student teachers felt comfortable to work on their own in solving problems but were always willing to assist their peers as stated in the following excerpt:

> *"I worked by myself. If my friends needed help I would work with them and explain how I understood it"* Mira (2007).

4.2.3.3 The lecturer

The lecturer's prior teaching experience positively influenced the interactions in the community. She had previously been involved in teaching at risk mathematics students which entailed her working with small groups of students to enhance their mathematical skills. The lecturer was also involved in teacher training workshops for unqualified mathematics teachers. She was therefore able to demonstrate insight about teaching and learning strategies which were suitable not only to reduce mathematics anxiety but also for enhancing students' basic mathematical skills and confidence. The lecturer's extract below corroborates this:

> *"I created an exciting environment so that they don't get stressed out – I think sometimes there is a lot of fear so to have a very calm classroom environment where there isn't any chaos helped. I make sure I facilitate interaction with the students, get them to ask a lot of questions and also I make sure the work I give them I sequence logically so it will take them from the one concept to the next. Well what was interesting initially, all of them were really struggling, then some students just burst out; some students started getting 70%'s and they would tell me themselves that this is not what they normally get"* (Lecture, 2007).

She also demonstrated that she was au-fait with the MIP aims and was therefore able to provide a supportive and stimulating learning environment for the student teachers. This was borne out by the subjects. For example one interviewee stated:

> *"I feel the lecturer puts herself in the students' shoes. You would say that she's like one of the students; she wants to get us doing the work. She will say that "I don't know, don't you have a solution?" She will do that and she gives you the feeling that you can do that"* (Sandy, 2007).

The lecturer encouraged social interaction amongst the students. She also encouraged an acceptance of one another's personal feelings and individual differences. The student teachers felt valued and enjoyed the personal attention that was given by the lecturer. Such intrinsic motivation was one of the factors that contributed to an improvement in the student teachers' performance. A quote from the lecturer's interview that supports the above statement is the following:

> *"I get them into the idea that maths can actually be fun because it's not just about standing and learning, it's about engaging with one another and the different kinds of materials and of course with feeling success, I do something in class that make them realise that they can also do this and I'm also very positive. I would walk around and boost their self-esteem so that they can walk out the class and their shoulders are up high. I would constantly tell them how good they are and how brilliant they are and how clever they are. I wouldn't allow any negative self-talk at all in the class. it just helps them with the feeling of self-worth and feel that they can actually accomplish - master the maths. So that's also I think one of the methods to do that - very encouraging"* (Lecturer, 2007).

The following remark, made by one of the student teachers interviewed, reinforces the lecturer's commitment to their learning:

> *"She would give us individual attention and she could see when you're uncomfortable. She would ask if everyone understood and you would say yes but have the odd look on your face that says 'oh no!' and she would notice that and come sit with you and explain"* (Mandy, 2007).

The student teachers also felt comfortable enough to ask the lecturer to review an activity when they did not fully understand. For example, the following quotes provide a good indication as to how the respondents viewed their MIP lecturer:

> *"The MIP lecturer wasn't the type of person if you got something wrong or you didn't understand that she will ignore you, she was patient, she would do it over and over and over again"* (Olive, 2007).

Another interviewee added:

> *"I got somebody who was very, very supportive. You can stop the lecturer and ask her what does that mean, she wouldn't mind answering you, she was willing to help and it made me feel comfortable"* (Ntobi, 2007).

4.2.3.4 Overview of the community

The community was made up of a diverse range of subjects who shared the same object. The safe and comfortable learning environment together with the supportive role played by the peers and lecturer constructed an environment that was different from other learning communities outside the MIP environment. It was unique in the sense that the subjects were aware of each others' weak mathematics foundation, they felt they were all in the same 'boat' and needed to support and encourage each other. This allowed the student teachers to be open and honest about their mathematical shortcomings which made collaborative work more effective. This also allowed the student teachers to carry out their activity in a supportive and caring environment in which the MIP operated.

4.2.4 The rules

The rules define how the subjects must adjust to the community. The rules component refers to explicit and implicit regulations that influence the actions and interactions within an activity system. In this section the student teachers' knowledge and understanding of these regulations are discussed.

Some of the rules that mediated the relationship between the subject and the community were constructed solely by the lecturer. The following excerpt points out the explicit and implicit rules identified by the lecturer:

> *"They had to do homework every single time. They had to attend; 100% attendance and 100% participation; they had to participate in the lessons and they have to ask questions; if there was anything going on if they don't understand anything they needed to ask at anytime. So I did different things all the time but the rule was always that you could ask a friend - when you struggle you can sit with somebody"* (Lecturer, 2007).

The explicit rules, e.g. attendance, class tests, assessments, and homework were manifested as marks, through formative and summative assessment allocated to the students.

The evaluation and assessment activities of each student teacher with regard to their understanding of learning and teaching mathematics were on-going in the MIP classroom. The lecturer maintained records of class tests, class assignments and individual and group work undertaken by the student teachers. The student teachers indicated that the assessments received allowed them to keep track of their performance and understanding of mathematical concepts taught. The following excerpts provide an example of a student teacher's reaction to the evaluation and assessment activities:

> *"We wrote tests; a lot of spot tests which means that we constantly had to be prepared for a test. I feel that was good because then I have to go home and go over my work because I could get a test at any time"* Mandy (2007).

Only 42% of the students identified explicit rules and its association to assessment that was quantified as marks. However, one respondent recalls an explicit rule with regards to homework and assessment:

> *"Yes, there was one specific rule where we had to do our homework and then she gave us 10 marks and that would also count for our final mark for the assessment"* (Olive, 2007).

In contrast, 58% of the student teachers interviewed did not identify any explicit rules and assumed that the basic university rules that applied to their other lectures also applied to the MIP class. With regard to implicit rules it was quite interesting to note that all of the interviewees identified at least one or more implicit rule. The following implicit rules emerged in the interviews with the candidates: it was expected that all members of the community would collaborate; socially interact in an appropriate manner; respect and accept point of views of other members in the MIP classroom; express and share ideas; accept one another's personal feelings and individual differences.

Many of the explicit and implicit rules were embedded within the structure of the planned lessons. The student teachers noted the following as a basic lesson structure in the MIP class:

- Being early for class;
- Starting the lesson with correction of homework;
- Recapitulation of previous lesson's concepts;
- Introduction of new lesson with the use of a variety of teaching and learning resources, e.g. use of objects, overhead projector, interactive worksheets, etc.;
- Freedom to ask questions or clarify misunderstandings and work in groups or individually;
- Scope for the lecturer to walk around the class, providing individual or group assistance; and
- Setting homework as preparation for the next lesson.

The structure of the planned lessons in the MIP class allowed independent, individual and group participation. The learning and teaching strategies (see Table 4.3) afforded the student teachers various opportunities to develop their mathematical understanding. It also enabled them to explore and experiment with various techniques to solve a problem. The student teachers were encouraged to think and discuss how they arrived at solutions to problems, to share this process with peers and more importantly not to be afraid to ask questions if they did not understand any section of the mathematics lesson. The structure of the lesson thus established the rules within the activity. The rules enabled the members of the community to interact with one another other in multiple ways to achieve the object of the activity.

4.2.5 The division of labour

The division of labour refers to the different roles undertaken by the members of the community, i.e. lecturer, peers and student teacher in achieving the object. The use of the different teaching and learning strategies and the changing roles of the members of the community allow for social interactions whilst the members of the community share in the responsibility for the student teachers' learning and teaching of mathematics.

Based on the implementation of the planned lesson, all members of the community were involved in varying roles in achieving the object. At times the lecturer undertook many roles, ranging from facilitator, motivator, modeller, co-ordinator, teacher and expert. The student teachers used the following descriptors when asked to identify the role of the lecturer in the MIP classroom, viz. teacher, supporter, empathizer, advisor, motivator. There were also times when the roles were reversed and the student teachers, in many of their group activities, acted as the facilitator, motivator, modeller, coordinator, and expert in assisting their peers.

The student teachers acknowledged that interacting with a more capable peer or the lecturer often allowed them to perform tasks that as individuals they were not capable of doing without support. The following respondent expresses her view on assistance from a more capable peer:

> *"If I don't know how to do a solution and another person in the class does, she will come and explain everything or what she knows, it really helped me to understand, I can see where I went wrong, we really worked well together" (Jane, 2007).*

This contrast between assisted and unassisted performance identified the link between development and learning that Vygotsky called the ZPD.

Working within the ZPD, the student teacher interacting with the lecturer or peer/s (some more capable than others), were able to achieve an understanding of mathematical tasks which he/she would not otherwise have been able to achieve individually. Collaborative learning within the ZPD-orientated teaching (Kinard & Kozulin, 2005) leads to greater awareness of what the student already knows and what they still don't know. This will allow the student to request missing information from the teacher or more capable peer/peers.

4.2.6 The object

The object in the AT system, is the physical or mental product that is sought and acted on by the subject (Jonassen & Rohrer-Muphy, 1999). It is the central issue that represents the intention that motivates the activity. The object of the activity in this study is for the student teachers to enhance their learning and teaching knowledge of mathematics. The student teachers' responses from a sort cards exercise, together with their test scores and graphical and written reflections, formed the main source of evidence in reporting on the findings in this section.

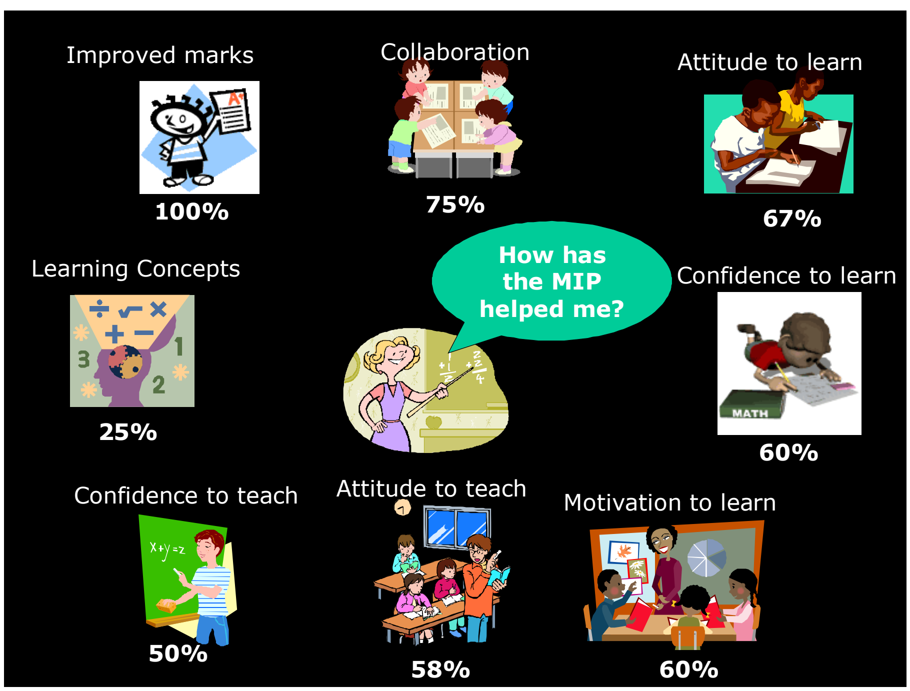

Figure 4.2 Analysis of 'sort cards' exercise

The subjects were given eight illustrative sort card, shown in Figure 4.2, they had to arrange these cards according to which aspect had made the most significant to the least significant contribution to their learning and teaching of mathematics whilst in MIP. They could also leave out cards if they so wished. Figure 4.2 indicates that all the student teachers had acknowledged that the MIP had definitely improved their performance in mathematics. The second outcome evident in figure 4.2 was collaboration. This strategy was something new for many of the student teacher as it was not used very often in their mathematics classroom at schools. They were able to discern the benefits gained from working in groups. This is evident in the following quote:

> *"I found that working with peers in a group was something new for me. I didn't do that before so I engaged myself with the group and that had made my understanding of mathematical concepts more easier for me. I became more comfortable with mathematics and I really enjoyed the group work"* Vusi (2007).
> .

The third important outcome from the sort card exercise was the student teachers' confidence and attitude towards learning mathematics. As an example one of the subjects acknowledges:

> *"I don't think I'm scared of maths any more as I used to be. I find maths exciting now and prior to that at high school maths used to be a chore that you did not want to do like washing the floors or something but now it's far more exciting just because I am a little bit more confident and I have a little bit more tools to tackle it with"* Fran (2007).
> .

This shift had also resulted in the student teachers being more motivated to learn mathematics. As Sandy (2007) states:

> *"I was always afraid to do maths because I thought I was stupid and I don't understand maths but being in the MIP has made me understand mathematics and I feel comfortable doing maths. Now I'm definitely motivated to learn maths".*

The improved mathematics grades and the subjects' ability to successfully complete mathematical tasks created a shift in their perception of learning mathematics.

In contrast to the subjects' confidence and attitude to *learn* mathematics 60% and 65% respectively, the results from sort card exercise in Figure 4.2 show a lower confidence and attitude to *teach* mathematics, 50% and 58% respectively. The student teachers felt that they were not ready to teach mathematics although their marks had improved in the subject.

Thabi (2007) stated:

> *"I don't have confidence in teaching maths. Because when you teach you must expect some questions so you must be able to answer those questions and people will come up with different questions and need different answers; so you must be prepared. So I'm still nervous to teach maths".*

In the interview with the MIP lecturer she did acknowledge that more time should have been spent on mathematics didactics. However, due to time and the curriculum constraints this was not possible. It should also be noted that the student teachers were only in their first year and their confidence and competence in teaching mathematics is at a developmental stage.

Finally, the response to the sort card that categorized the learning of mathematical concepts, depicted in figure 4.2, reveals that only 25% of the subjects acknowledged the learning of mathematical concepts as one of the factors that had made an overall impact on their learning and teaching of mathematics i.e. the student teachers were asked if their method of learning mathematics had changed. One of the subjects acknowledges:

> *"I'm not as anxious to learn new concepts in maths now because I always try and break it down to the simplest form"* Fran (2007).

Whilst, another subject responds:

> *"I think I still stick to the learning method that I used at school"* Mandy (2007).

Many of the subjects when asked to arrange the sort cards in order of most significant to least significant, did not give attention to the learning mathematical concepts sort card. This could be due to the following reasons. Firstly, although a change has taken place in the way subjects learn mathematics, they were not aware of this change in the learning process i.e. there was no self-awareness of the processes involved in learning mathematics. The second reason could be that the subjects did not fully understand what was expected of them from that particular sort card. In retrospect, I think greater clarification on what was expected in the sort card dealing with 'learning concepts' should have been given to the subjects.

The next two sub-sections i.e. test scores and graphical and written reflections formed the secondary source of evidence. The evidence from these sources is used to strengthen the findings from the primary source with regards to improvement of student teachers' mathematics performance and perceptions of learning mathematics.

4.2.6.1 Test Scores

Figure 4.3 shows a comparison between the diagnostic tests written by the student teachers at the beginning of the year with their final mathematics mark, which is made up of class tests, assignments and end of year exam mark. All the student teachers in the MIP had improved their mathematics performance. Extracts from the following two respondents reinforces the above point:

> *"My grades improved dramatically and this year I started off again in the main stream mathematics class and my grades are still doing quite well"* Fran (2007).

Another adds

> *"Oh yes, my marks improved gradually but definitely. I know it and I've seen it. Not to the best of the best but I saw an improvement after each test, after the MIP classes, I saw an improvement"* Morgan (2007).

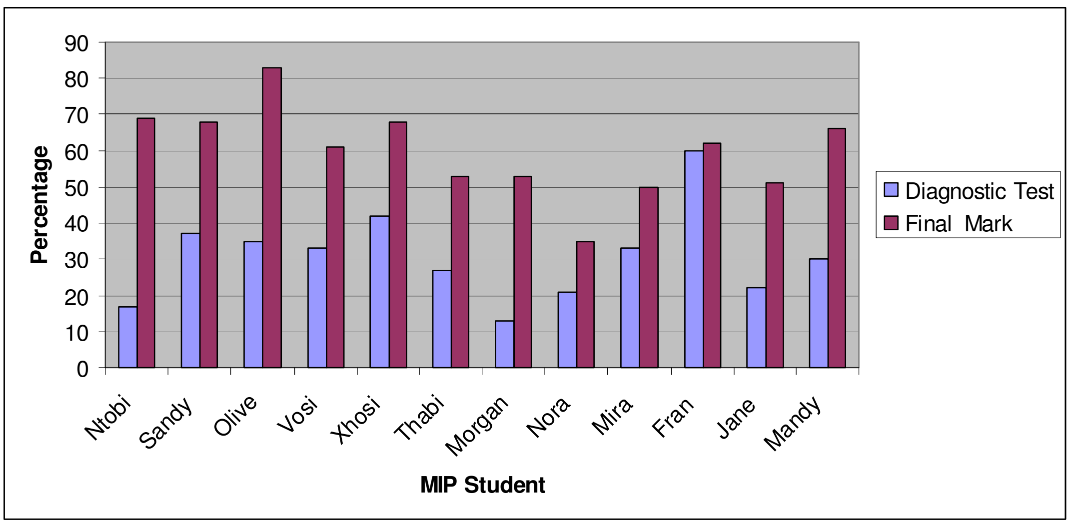

Figure 4.3: A comparison between the MIP student teachers' mathematics diagnostic test results with their final mathematics mark

The results from the above table corroborates with the subjects response from the sort cards (Figure 4.2), in which all the subjects responded to the MIP positively influencing their mathematics performance.

4.2.6.2 *Written and graphical reflections*

This section examines the third source of evidence i.e. the graphical and written illustrations created by the MIP student teachers whilst in the MIP.

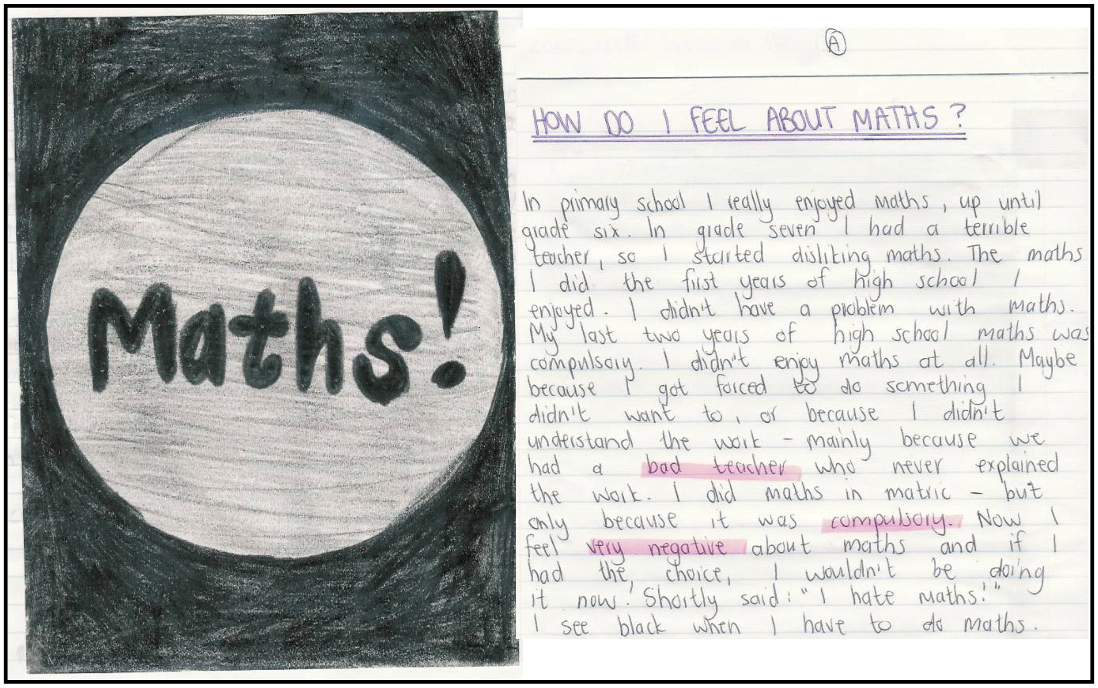

Figure 4.4 An illustration and written reflection on a student teacher's mathematics learning: An example

In Figure 4.4 a written and graphical illustration created by one of the student teachers in the MIP reflects her initial concern for and fear of learning mathematics. Her apprehension towards learning mathematics was due to her negative school-based experiences of learning mathematics. A similar trend was also evident with other student teachers' reflections on their prior mathematical experiences. However, for some of the student teachers who reflected on their present mathematical experiences in the MIP, there was acknowledgment of a gradual change in their attitude from being anxious and scared to beginning to feel more relaxed and confident. The written and graphical illustration in Figure 4.5 depicts a student teacher's reflections of learning mathematics whilst in the MIP. Other student teachers' reflections on the MIP also revealed they felt nervous and hesitant to approach mathematical tasks but given the appropriate guidance, support and mathematical skills they felt motivated and confident to learn mathematics and succeed.

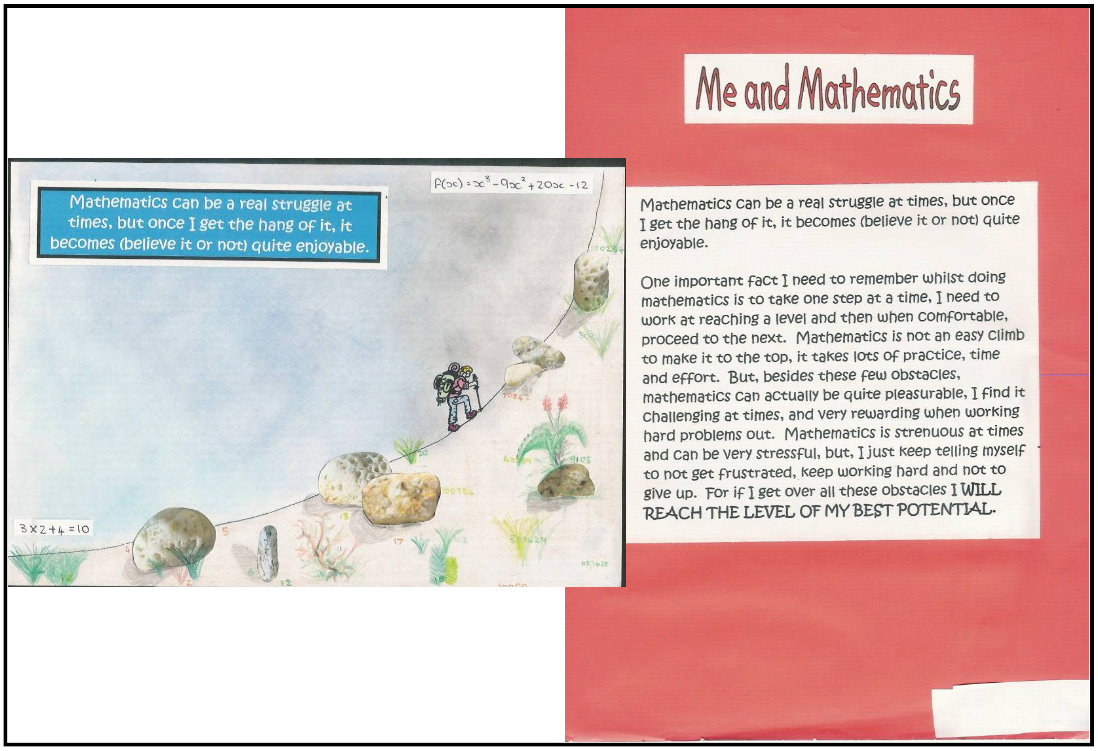

Figure 4.5 An example of a student teacher's reflection of mathematics learning whilst in the MIP

Referring back to Figure 4.2 the statistics support the observation made from the written and graphical reflections of the subjects. Sixty seven percent of the subjects felt that the MIP had definitely improved their attitude towards learning mathematics and a significant 60% of subjects also conceded that the MIP had increased their confidence to learn mathematics.

4.3 Integrating the findings of the six AT components

The foregoing sections presented an insight into the MIP in terms of the individual components of the AT framework. Although AT provides a socio-cultural lens through which the analysis of human activity could be examined by focusing on each component individually, it also provides a holistic perspective in which the teaching and learning activities could be understood by integrating the components (Hung & Wong, 2000; Janassen & Rohner-Murphy, 1999). Thus in order to respond to the research questions of this study, these components need to be considered as an integrated system, i.e. the whole activity is greater than the sum of its parts. This is due to the fact that activity theory components are intertwined and are associated with various aspects of the whole activity. Therefore, the AT components need to be considered as an integrated system.

Given the above, and in order to fully understand the student teachers' activity in this study in relation to the MIP, the inter-relationships between the components involved in the activity need to be examined holistically (Refer to Figure 4.6).

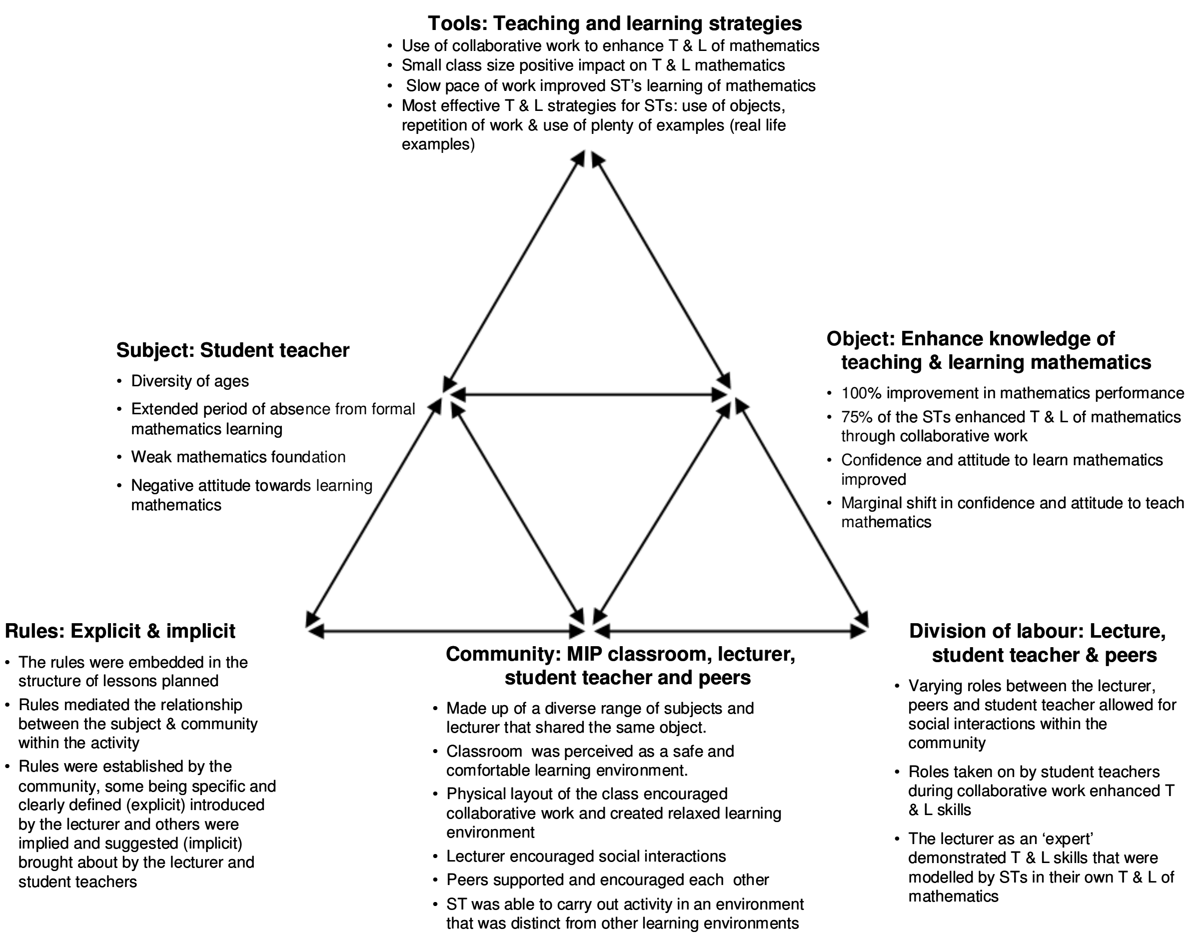

Figure 4.6 Discussions on findings plotted onto Engeström's activity theory system

The upper part of Figure 4.6 (subject, object and tools) shows a section of the AT model used to report on the findings related to how the subjects were able to engage with the mediated teaching and learning tools in order to reach the object. The lower half of the triangle (rules, community and division of labour) reports on the findings focused on how the social environment within the MIP classroom influenced the student teachers' perceptions of learning and teaching mathematics. The activity system as a whole examines the mediated activity within a social context of the MIP classroom.

Figure 4.6 consolidates the findings and highlights key aspects of the AT components that have influenced the subjects' learning of mathematics and their teaching abilities. This figure highlights that the change in attitude and perceptions as indicated by the test scores and sort card selection process cannot be attributed to just one aspect of the MIP implementation strategy. Rather the change is a result of the collective mediation of the components. Important aspects from this figure include the rules, community and division of labour which created the learning environment of the MIP. The inter-relationship of the activities within these components transformed the subjects into achieving the object of the activity. For example, the relationship between the implicit rules i.e. sharing ideas, socially interacting in an appropriate manner, acceptance of each others' feelings and individual differences with the community, i.e. the classroom ambience, collaborating with peers and the lecturer's positive attitude, which was mediated by the division of labour, i.e. the varying roles that were demonstrated by the subjects in collaborative work and the lecturer's role as facilitator, motivator, teacher, etc., influenced the subjects perceptions of learning and teaching of mathematics.

4.4 Conclusion

The synthesis of the findings in the preceding figure identifies a series of MIP strategies, and offers insight into the question: How have student teachers' experiences in the MIP shaped their perceptions of learning and teaching mathematics? This figure expounds on the *How* of the main research question.

The following chapter presents the interpretation of these findings as a means of offering a conclusive response to the research questions. In addition, the recommendations arising from the research will be addressed and concluding remarks made.

Chapter Five

Overview, interpretation, recommendations and conclusion

5.1 Introduction

This chapter provides an overview of the study, interprets the findings that were presented in Chapter Four and makes recommendations in respect of the MIP. Implications of the research findings for addressing the problems related to mathematics learning of at risk student teachers in teacher education programmes are also discussed. The chapter concludes by examining the limitations of this study, and finally reflects on the scope for further research in this field.

5.2 Overview of the study

This study was prompted by national concerns regarding the state of mathematics' teaching and learning in the South African education system. Added to these concerns was the lack of qualified and competent mathematics teachers (Mangena, 2001; Pandor, 2005). This background to the research problem was described in Chapter One. The specific research problem that was the focus of this study is situated in the higher education landscape. The study focused on first year at risk education students who entered the four year pre-service teaching degree with a weak foundation in mathematics. This meant these students had great difficulties with mathematics content knowledge as well as poor attitudes towards mathematics learning. The mathematics intervention programme was designed to address the shortfall in student teachers' knowledge and to try to change attitudes to teaching and learning mathematics. This research study investigated how a mathematics intervention programme, at an institute of higher learning, shaped **student teachers' perceptions of learning and teaching mathematics.**

In Chapter Two a deeper understanding of the theoretical background to the research problem was acquired. Four areas of the literature were examined, viz. students' perceptions of learning and teaching mathematics; effective mathematics intervention programmes; theoretical perspectives of learning and teaching strategies associated with mathematics; and activity theory as a theoretical framework for the study of different forms of human activities such as learning activities of students. The chapter concluded with a motivation that activity theory presented a suitable framework within which to investigate how the mathematics intervention programme shaped student teachers' perceptions of learning and teaching mathematics.

Following on this, Chapter Three presented a detailed overview of the research design and the methods for the conduct of this study. In particular this chapter motivated an interpretivist paradigm and outlined the rationale for the use of methods to collect and analyse qualitative data from amongst a sample of the student teachers in the MIP. The empirical investigation targeted the collection of three types of data, viz. interviews, test scores, and written and graphical reflections.

The resultant findings, which are presented in Chapter Four were contextualized within an activity theory framework. The six components of the activity theory system were used as a framework to discuss the findings. This was followed by a synthesis of the findings, i.e. their relationships and inter-relationships within the MIP activity and how these activities have influenced the at risk student teachers' learning and teaching of mathematics. The AT framework provided a lens with which I was able to understand the MIP in greater depth. Moreover, I was able to examine the core of the MIP, explore different facets of the programme, and obtain insight into aspects of how the MIP environment contributed to the at risk students teachers' understanding of learning and teaching of mathematics.

The evidence presented in Chapter Four confirms that the student teachers' perceptions of learning and teaching mathematics, in the sample that was selected for the study, had changed. There are three indicators of this:

- The results of the final component of the interviews during which the subjects' responses, through the use of sort cards, indicate that their motivation, attitude and confidence to learn mathematics had improved since they commenced participating in the MIP.
- The written and graphical reflections of the subjects on their mathematics experiences in the MIP which portrayed a positive attitude towards mathematics and mathematics learning; and
- The improved mathematics marks amongst the subjects.

The findings thus inform us about important outcomes of the mathematics intervention programme in respect of changed perceptions of at risk student teachers. The findings also point to aspects of the MIP that were contributory to these outcomes. The main aim of the study was to investigate *how* the MIP shaped student teachers' perceptions of learning and teaching mathematics. It is therefore necessary to conclude this study by reflecting on the findings so as to underscore how the MIP has effected this change.

5.3 How has the Mathematics Intervention Programme shaped the student teachers' perceptions of learning and teaching mathematics?

The findings indicated two important aspects of the MIP which promoted a positive outcome in respect of the way in which student teachers' perceived teaching and learning of mathematics. These were aspects relating to the:

i. classroom environment; and
ii. teaching and learning strategies used in the MIP.

Importantly (i) and (ii) above were not mutually exclusive contributors to the positive outcomes. Rather it was the ongoing *interaction* between the elements of the classroom environment and specific (i.e. not all) teaching and learning strategies applied by the MIP lecturer, which jointly contributed to a change in perception amongst the subjects as reflected in Figure 5.1 below. (Figure 5.1. is discussed further in the following two sub-sections).

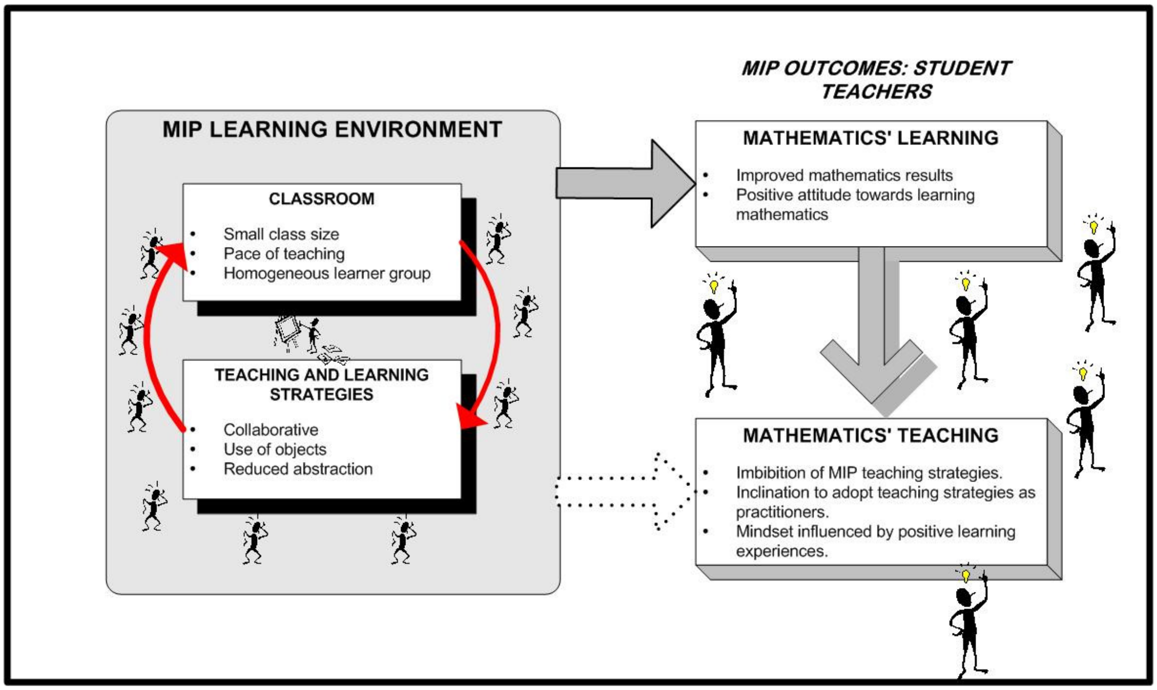

Figure 5.1: **Overview of how the MIP influenced student teachers' learning & teaching of mathematics**

5.3.1 Mathematics intervention programme: classroom environment

A key theme which emerged through the analysis of the student teachers' interviews was the facilitating role of the MIP classroom environment, as shown in figure 5.1. Aspects of this environment were emphasized by every interviewee without exception. The small class size, the slower pace of learning and teaching and the homogeneous learner group collectively provided uniqueness to the environment which was referred to by student teachers during the interviews. Other studies referred to in Chapter Two, such as Gervasoni (2005), also identified similar elements of the classroom as being contributory to student teachers overcoming their negative perceptions of mathematics.

Secondly, the findings in Chapter Four also point to the classroom environment as a crucial component in guiding students towards an interactive and constructivist approach in their learning activities. This is demonstrative that the MIP classroom environment was able to facilitate higher-order thinking and meta-cognition (see Pantel, 1997 in Chapter Two) amongst the student teachers, i.e. the classroom instilled a self-awareness in the student teachers of their own cognitive abilities which they then applied to the tasks in the MIP.

A third finding in Chapter Four highlighted the characteristics of the MIP learning environment as being relaxed, non-threatening and comfortable. As a result the student teachers in the MIP class environment felt confident to:

- seek help from the lecturer and peers with regards to mathematical problems they were experiencing;
- try out new ways of solving mathematical problems;
- voice their opinions, debate and discuss mathematical issues with the lecturer and peers.

These positive outcomes were also identified in other studies dealing with collaborative learning strategies discussed in Chapter Two, e.g. Noddings (1990), Mathematics Association of America (1991), Cobb (1992), Adams & Hamm (1996). The confidence gained by the student teachers helped them to realize their self-worth, as they felt valued and respected in the MIP learning environment. This in turn resulted in a positive attitude and improved confidence towards learning and teaching mathematics.

The above findings were examined within the AT framework. The overall characteristic of the MIP classroom environment was attributed to the *inter-relationship* (Figure 5.2) between the following components in the AT framework:

- the relationship between the *subject* and members of the *community*;
- the creation and implementation of the *rules;* and

- the way in which the *division of labour* occurred.

Figure 5.2 highlights the section of the activity theory model that was used to report on the MIP learning environment in Chapter Four. The inter-play of the above components, viz. the subject, rules, community and division of labour collectively created a learning environment that impacted positively on the student teachers' perception of learning and teaching of mathematics.

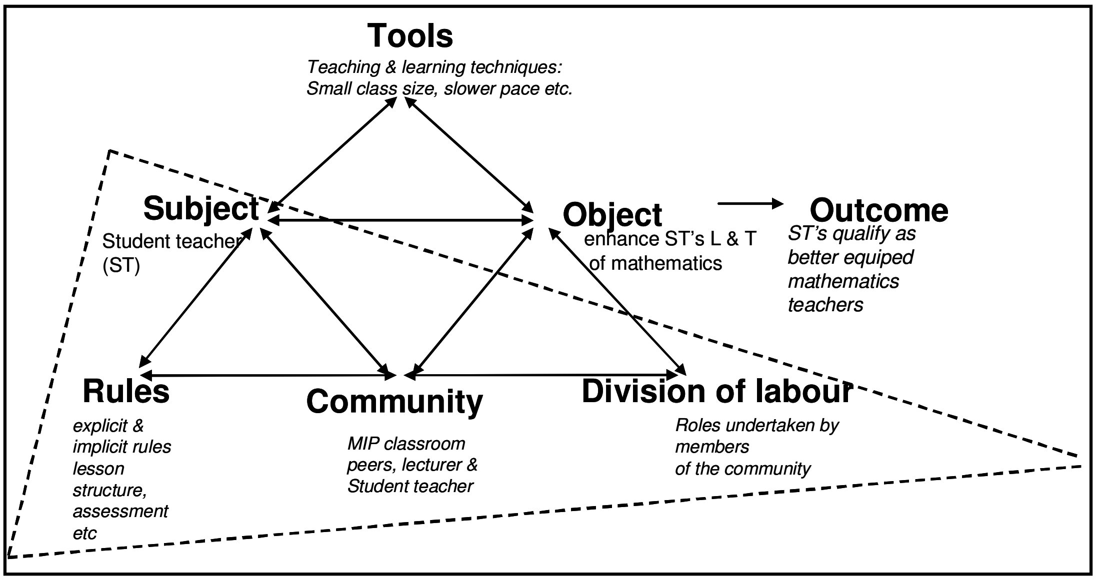

Figure 5.2: **Section of Activity Theory model used to report on the learning environment**

Finally, the emphasis of this aspect of the MIP, viz. the MIP classroom environment, is also borne out in a number of other studies that were discussed in the literature review, e.g. Roth & Roychoudhury (1994), Schiefele & Csikszentmihalyi (1995), and Brady (2006). These are examples of studies which also stressed the importance of the classroom environment in enhancing students' learning of mathematics. As such this highlights the important role of constructivist teaching and learning environments generally in changing student teachers perceptions of learning and teaching mathematics.

5.3.2 Teaching and learning strategies

Various teaching and learning strategies were used in the MIP class to scaffold and build on the student teachers' knowledge of learning and teaching mathematics. These strategies assisted the diverse group of student teachers who had varied learning needs. Figure 5.3 shows the section of the AT model that was used in Chapter Four to report on the impact of the teaching and learning strategies used in the MIP, to enhance the student teachers' knowledge of learning and teaching mathematics.

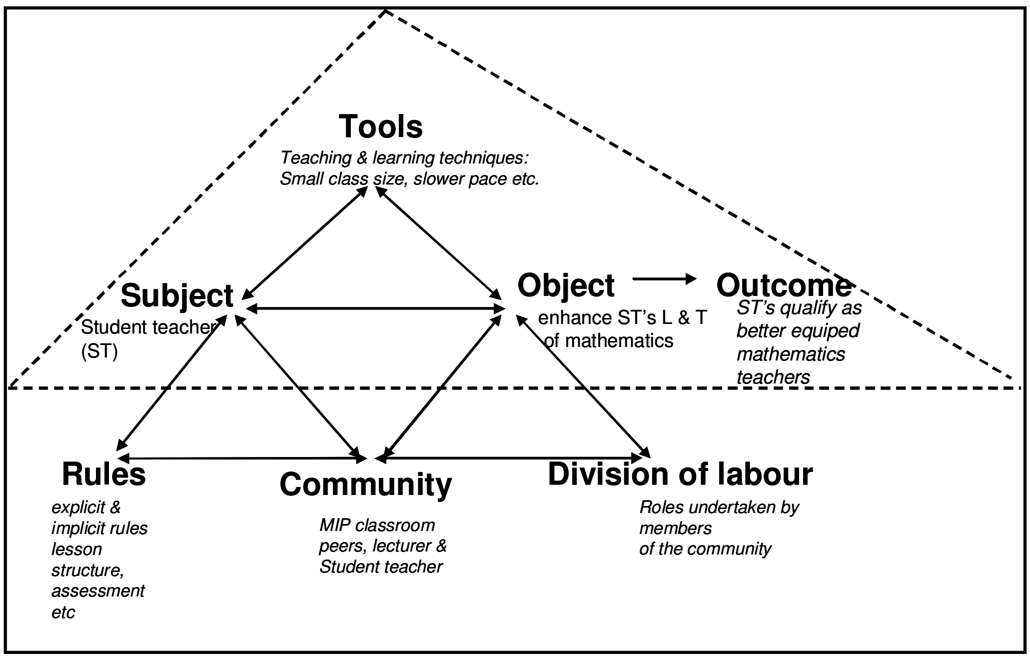

Figure 5.3 : Section of the Activity Theory model used to report on the impact of the mediated tools on at risk student teachers' learning

Chapter Four reported on the individual demarcated components in Figure 5.3. The significance of Figure 5.3 is that it highlights the importance of the mediating activity of the tools in transitioning the subject more successfully to the object. The mediating tools in the MIP, i.e. the teaching and learning strategies, played a critical role in fostering a change in the student teachers' perceptions of learning mathematics. The following teaching and learning strategies (see Figure 5.1) were identified as the major contributors to the student teachers' learning of mathematics:

- **Collaborative work:** this encouraged student teachers to be more verbal with regards to their mathematical thoughts thus allowing them to:

  - build confidence to solve problems that they could not solve on their own;
  - overcome their fears and practice new techniques;
  - build on their existing understanding of mathematics by learning from others in their groups; and
  - benefit from the social interaction that was facilitated by group-work.

- **Use of concrete objects:** the use of visual and concrete objects, contributed to the student teachers' ability to connect the concrete understanding to abstract mathematical processes with confidence. These tasks contributed to greater motivation and interest in learning mathematics. This outcome enhanced the student teachers' understanding of mathematical concepts and more importantly it promoted a better understanding of these concepts to real-life situations.

- **Use of real-life examples and repetition of mathematical concepts:** these strategies, which are not dissimilar to the use of concrete objects discussed above, provided a scaffold to the student teachers' understanding of mathematical concepts. They were able to relate these concepts to the real-life situations thus allowing mathematical concepts to be viewed as more practical and meaningful.

The abovementioned points to the effectiveness of these particular teaching and learning strategies in enhancing the at risk student teachers' learning of mathematics in the MIP. What is clear is that the aforementioned strategies, which emphasise social interaction and students' drawing on personal experiences to understand the use of concrete and practical examples, were those that were most beneficial to the student teachers' learning experience. This is not dissimilar to the views expressed by Brady (2006) in which he states that such constructivist teaching strategies, view learning development as social, as the result of the learner's social context in which learning occurs and cultural, their experiences as a result of the interactions in which they have been participants.

However, the various teaching and learning strategies used in the MIP did not have the same impact on all the at risk student teachers, as evident in Chapter Four, Table 4.3. Two distinct results that can be deduced from the tool mediated activity were firstly, that all the student teachers were optimistic in acknowledging their improved results. A second important observation that emerged from the findings was that the teaching and learning tools which student teachers considered to be effective for their own learning of mathematics (see Table 4.4) were also recognised as tools that they would be inclined to adopt as mathematics teaching practitioners.

Finally, it can be concluded, that the classroom environment and teaching and learning strategies used in the MIP (refer to Figure 5.1), were beneficial to the student teachers in two ways:

i. The first, and perhaps more important benefit, is that the student teachers were able to engage in mathematics learning experiences similar to that of a pupil within the school system. This was significant in providing the student teacher with pedagogical knowledge from an "insider" perspective.
ii. The second is that these elements appear to jointly contribute to the improvement of their knowledge of mathematics, i.e. their content knowledge;

5.3.3 Student teachers' perceptions of learning and teaching mathematics.

Figure 5.1 draws attention to a distinction between the student teachers' perceptions of *learning* mathematics and the way they perceived the *teaching* of mathematics. The findings suggest that the following factors contributed to the student teachers being able to perceive the learning of mathematics in a positive light:

- small class size;
- lecturer's attitude;
- varied teaching and learning techniques;
- individual attention;
- peer support;
- visible improvement in their mathematics results.

Evidence from Chapter Four (refer to Table 4.1) reveals that the majority of the at risk student teachers who entered the MIP did so with a negative attitude and a fear of learning mathematics as a result of their previous experiences in the schooling system. Sections 5.3.1 and 5.3.2 above alluded to the importance of both the constructivist teaching and learning strategies used in the MIP classroom, and the learning experiences of the student teachers, which contributed to the positive shift in the student teachers' perceptions towards learning and teaching mathematics. The aforementioned is supported by many studies of mathematics intervention programmes which were reviewed in Chapter Two. Studies such as Schuck (1996), Bloom (1983), Doig et al. (2003), Gervasoni (2005), Lubinski & Otto (2004), Tchoshanov *et al.* (2001), Holt-Reynolds (1994) and Schoenfeld (1994, 1985) are indicative that that positive shifts in students' perception of mathematics is indeed possible albeit within different contexts.

Although a positive shift in student teachers' perceptions was noted in this study, there was a difference with regard to the student teachers' *learning* of mathematics and that of *teaching* mathematics. Only fifty percent of the student teachers interviewed conceded that they felt confident enough to teach mathematics lessons in their first year of teaching practice even though their results and attitude towards the subject had changed. Many of these student teachers remarked that they were not adequately prepared to manage mathematical queries that might arise in the classroom. Hopefully these first year students' confidence levels will grow by the time they graduate and enter the classroom as professional teachers. In any event, this highlights an area that requires further exploration as it will be useful to understand why such inadequacies prevailed.

Notwithstanding the lack of confidence to teach mathematics, the findings do indeed reveal that the teaching strategies used in the MIP were imbibed by the students in that they recognized these strategies as techniques that could be used in their own teaching of mathematics during teaching practice and later as professional teachers. This was a significant finding as it demonstrates the MIP had an impact on student teachers' perceptions of mathematics *teaching.*

5.4 Recommendations

The research recommendations presented here could be extended to other similar settings which require interventions such as the MIP. The analysis of the collected data and the findings of this study could benefit the design of other universities' intervention programmes. However, readers should be cautioned not to over-generalize the findings as they do pertain to a specific university setting.

Recommendation one: increased emphasis on didactics in the MIP

The findings revealed that although the mathematics intervention programme contributed to an improved attitude of at risk student teachers to learning mathematics, about fifty percent of the sample felt that they lacked confidence to teach mathematics. This underscores the need to provide more emphasis on the didactics component of the mathematics intervention programme.

In this regard, studies such as Tchoshanov *et al.* (2001) can provide guidelines such as the shifting of the learning environment of the intervention programme from the university classroom to a traditional school classroom to increase pedagogical skills and level of teaching performance. Additionally a micro-teaching component could be integrated into the intervention programme. This would allow at risk student teachers to become more receptive to mathematics activities, and to the dynamics of the teaching and learning of mathematics. A didactics component of the MIP should also ensure a strong evaluation cycle in which the lecturers are able to provide constructive feedback of practice teaching/micro-teaching, and thereafter incorporate corrective and remedial actions into the intervention programme.

Recommendation two: Intervention design to be informed by a profile-analysis of the at risk student cohort and the MIP lecturer

Having considered the findings, it is clear that there are specific aspects of the at risk student that need to be considered when designing an intervention such as the MIP. Although the findings do provide a clear perspective of the elements of the MIP which contributed to a change of perceptions, a profile-analysis of the at risk student will assist in fine-tuning the program. Thus the findings from this study will help inform the base design of the MIP. This should then be fine-tuned through a consideration of the particular group of at risk students. Additionally, careful consideration has to be given to the selection of the MIP lecturers. The findings of this study have shown that the background of the MIP lecturer combined with her specific skills, was an important factor in realising the positive outcomes.

Thus, it is crucial the design of the MIP be informed by the following information, in respect of key members of the intervention community:

- Student: the level of the students' formal knowledge of the subject at risk should be identified before they enter the intervention classroom. In addition, knowledge of at risk students' learning styles should also be gained. The information received could influence the teaching and learning strategies implemented in the intervention programme.

- Lecturer: the lecturer employed to teach at risk students should have the necessary skills and experience to interact in an intervention classroom environment. The lecturer should be knowledgeable with regards to creative, effective teaching and learning strategies to promote the students' learning and reduce anxieties.

Recommendation three: Use of activity theory as a tool for MIP design

There are a substantive number of studies in the literature which have used AT to understand the learning process in numerous educational settings. As Dayton (2000) points out, there are a growing number of researchers in a wide range of fields who value activity theory for its descriptive conceptual framework and the insights it provides into the numerous reasons why human behaviour and consciousness so effectively evade theoretical explanations. Thus AT appears to be a useful tool for the practice of empirical research.

In reflecting on the use of AT to conduct this research, it became clear that AT can also make a valuable contribution to designers of learning situations. The design of this MIP was not informed by a specific structured framework. Rather it emerged as a result of recognising the needs of the mathematically at risk students. Going forward, it is recommended that the design of the MIP be enhanced by using the AT framework to hone in upfront on *all* the components of the activity system related to mathematics learning. In this way the instructional designers of the MIP will have a more integrated approach.

5.5 Limitations of this study

As with similar studies of this nature there were several limitations. The normal limitations experienced by post graduate students engaged in part-time studies such as time constraints, and access to resources were a factor in this study. More importantly, as the journey through this investigation neared conclusion, I was able to reflect on the research process, and identified other limitations, which otherwise could have enhanced the research findings of this study. These pertained to:

- use of the observation technique to collect evidence; and
- the study of other mathematics intervention programmes around the country.

The observation of the at risk student teachers engaged in learning and teaching activities in the social settings of the mathematics intervention classroom, as well as observing them teaching mathematics lessons during teaching practice would have provided more depth and enriched the findings of this study. Observing at risk student teachers would have provided me with a reasonable understanding of the social interactions of the different role players in the MIP learning environment and their contributions to advancing the at risk student teacher's learning of mathematics. In addition it would have also strengthened the validity of the study by providing another element for triangulation.

The issue of generalization is another element of concern. As this study focused on a single case, it was therefore restricted to an in-depth investigation at one institution. However, had I also investigated similar mathematics interventions programmes at other South African universities, the findings could have been more generalisable within a South African context. However this was not possible given the amount of time I had available as well as the necessary resources to travel around South Africa. Furthermore the study of multiple cases would have diluted the type of rich and detailed data that I was able to collect in this single case study. This limitation should of course be noted in light of the interpretivist paradigm within which this study was conducted. In this paradigm the *transferability* of findings (refer to Chapter Three) as opposed to generalisability which is usually associated with the results of quantitative analysis, is of more importance.

5.6 Scope for further study

The findings from this study provide scope for further investigations. Valuable and useful investigations for further study that could emerge from this study are:

- A longitudinal study of the subjects of this study. Such a study should follow the student teachers into the classroom, post graduation, to investigate their effectiveness as mathematics teachers. The importance of such an investigation is that it would provide insight into the contribution of interventions, such as the MIP in breaking the vicious cycle referred to in Chapter One.
- The findings of this study also provide a basis for two comparative studies, viz.
  - a study of mathematics intervention programmes at selected teacher education programmes at other universities. This is important to extend the findings presented in this dissertation, and to produce a framework for the effective implementation of mathematics intervention programmes for student teachers; and
  - a study of selected intervention programmes in varying disciplines at other universities. This comparative study will be useful in making a contribution to our general understanding of how the needs of at risk students within South African higher education are catered for.

Finally, this study, like other studies that were highlighted in Chapter Two, reveals that a positive change in students' attitude/perceptions towards learning mathematics can result in improved mathematics performance. However, the same could not be concluded about improved mathematic performance and improved confidence to teach mathematics. There is scope therefore to investigate this relationship further. Such a study could also set out to establish if reducing anxiety levels will lead to increased confidence to teach mathematics.

5.7 Concluding remarks

The purpose of this study was to investigate if the MIP had influenced the student teachers' perceptions of learning and teaching mathematics. The use of the activity theory system as a framework to analyse and discuss the action and interaction between and within each component assisted with answering this question. Moreover, the results reveal that the student teachers' activities within the various components of the activity system did not exist in isolation from one another but rather within a system of dynamic and continuous change. Thus the usefulness of AT is borne out. As a result of using the AT framework as a lens for analysis and understanding, the investigation was able to dissect the MIP across all the components of its activity and also examine the relationships between the components. The results of this study were therefore enriched by the useful insights that were obtained through this process. This in turn therefore provided a more holistic understanding of how the MIP influenced a change in the student teachers perceptions of learning and teaching mathematics.

This study concludes that the mathematics intervention programme had a positive effect on the at risk student teachers' perceptions with regard to the following: Firstly, improving the student teachers' attitudes to, and level of confidence in learning mathematics. Secondly, by providing student teachers an opportunity to be exposed to teaching strategies that could be used when conducting mathematics lessons during teaching practice or as future mathematics teachers. Thirdly, improving student teachers' mathematics performance.

Overall the study provides some insight into how interventions can work in elevating the confidence of at risk students in a South African context. In particular the study highlights that it is indeed possible to break the vicious cycle of returning graduated student teachers with negative perceptions of mathematics into our classrooms. Although the study has not been able to provide evidence of how these students will actually perform as teachers of mathematics, it does however set the stage for further investigation in this regard.

Finally, the findings of this study provides insight as to how the problems related to mathematics teaching and learning, created by an unjust education system (pre 1994), can be overcome. Importantly though it should be noted that the MIP, like various other intervention programmes characterising the South African higher education landscape, are symptoms of the deeper consequences of apartheid education. The injecting of better equipped mathematics teachers into the school system, while important, needs to be located within an overhaul of the school system as a whole so that other problems such as lack of physical infrastructure, large class sizes, and teaching and learning resources are simultaneously addressed.

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Lecturer Interview Schedule

Research Question: How has the MIP shaped student teachers' perceptions of learning and teaching Mathematics?

1. Subject (Lecturer)	• Experience/ Mathematics qualification • 1st Language	
2. Tools (materials, teaching techniques etc.)	• What teaching techniques were used in the MIP lessons & how were they used? • What resources were used in the MIP lesson & how were these used? • How did the language of teaching and learning (English) impact on the students' learning of mathematics? • In your opinion how did class size and pace of work impact on the students' learning of mathematics?	
3. Rules (principles of control – which afford and constrain behaviour.	• How have the following rules impacted on the MIP outcomes: ➢ Curriculum ➢ Time Frame ➢ Structure of lesson ➢ Notes ➢ Subject assessment criteria • Where there any specific rules with regards to the way the students in the MIP class were expected to behave? Explain	
4. Division of Labour (the roles undertaken by the members of the classroom	• Was there team effort or individual effort for many of the tasks? Explain • How did you think students felt to participate in class discussions? • How did you perceive the student's function in the MIP classroom? • How did you perceive your function	

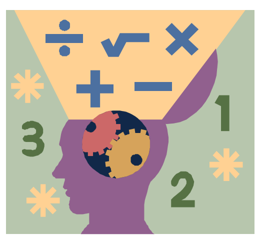
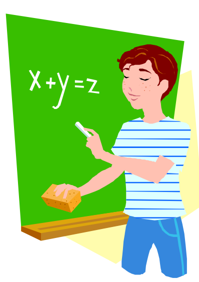
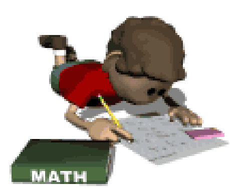
community)	in the MIP classroom?	
5. Community (the classroom setting)	• How did you support the students in the MIP class? • How did students support each other in the MIP class?	
6. Objects (student teachers' understanding of learning and teaching mathematics)	• Can you identify the outcomes of the MIP? • What was the purpose of the MIP? • Why did you engage in the process? • What was acted on and transformed during the process? • Which technique/s in the MIP would you encourage your students to use in teaching and learning of mathematics? Why?	
7. Outcomes (Expected outcome)	• How do you think the following has helped the students in the MIP: ➢ Improving grades ➢ Motivation to learn mathematics ➢ Motivation to teach mathematics ➢ Collaboration/group work ➢ Learning mathematics concepts ➢ Confidence in teaching mathematics ➢ Attitude towards teaching mathematics ➢ Attitude towards learning mathematics	

Student Interview Schedule

Research Question: How has the MIP shaped student teachers' perceptions of learning and teaching Mathematics?

1. Subject (student teacher)	• Age (card with categories) • Gender (observation) • Mathematics qualification • 1st Language	
2. Tools (Materials, teaching techniques etc.)	• What teaching techniques were used in the MIP lessons? How were these used? • What resources were used? How were these resources used? • How were new topics introduced/taught? • What technique/s used in the MIP was most effective for you in learning mathematics? • How did the language of teaching and learning (English) impact on your learning of mathematics?	
3. Object (MIP)	• What benefits did you derive from the MIP? • Which technique/s used in the MIP would you use in teaching a mathematics lesson?	
4. Rules (Principles of control – which afford and constrain behaviour.	• How did you feel about the way the class lesson was structured? • Where there any specific rules with regards to the way you were expected to behave in the MIP class? Explain • Do you think students felt comfortable to participate in class discussions? Why?	
6. Division of Labour	• Was there team effort or individual effort for majority of the tasks?	

<table>
<tr><td>(the roles undertaken by the members of the classroom community)</td><td>(Provide details for team effort)
What did you see as the lecturer’s responsibility in the MIP classroom?
What did you see as your responsibility in the MIP classroom?</td><td></td></tr>
<tr><td>7. Community (the classroom setting)</td><td>Did your lecturer support you in the MIP classroom? If so, how?
Did your peers support you in the MIP class? If so, how?
How did you seek help for difficult tasks in the classroom?</td><td></td></tr>
<tr><td>5. Outcomes</td><td>From the following explain how the MIP has helped you in: (please indicate if the MIP has <u>not</u> helped you in any of these)
Improving grades
Motivation to learn mathematics
Motivation to teach mathematics
Collaboration
Learning mathematics concepts
Confidence in teaching mathematics
Attitude (to what?)</td><td></td></tr>
</table>

1. Improve marks 	2. Confidence to learn maths 
3. Motivation to learn 	4. Collaboration/group work 
5. Learning mathematic concepts 	6. Confidence to teach maths 
7. Attitude towards teaching maths 	8. Attitude towards learning mathematics 

Cape Peninsula
University of Technology
Faculty of Education and Social Science

Dear XXXXXX

Investigating Student Teachers' perceptions of learning and teaching mathematics whilst in the Mathematics Intervention Programme (MIP)

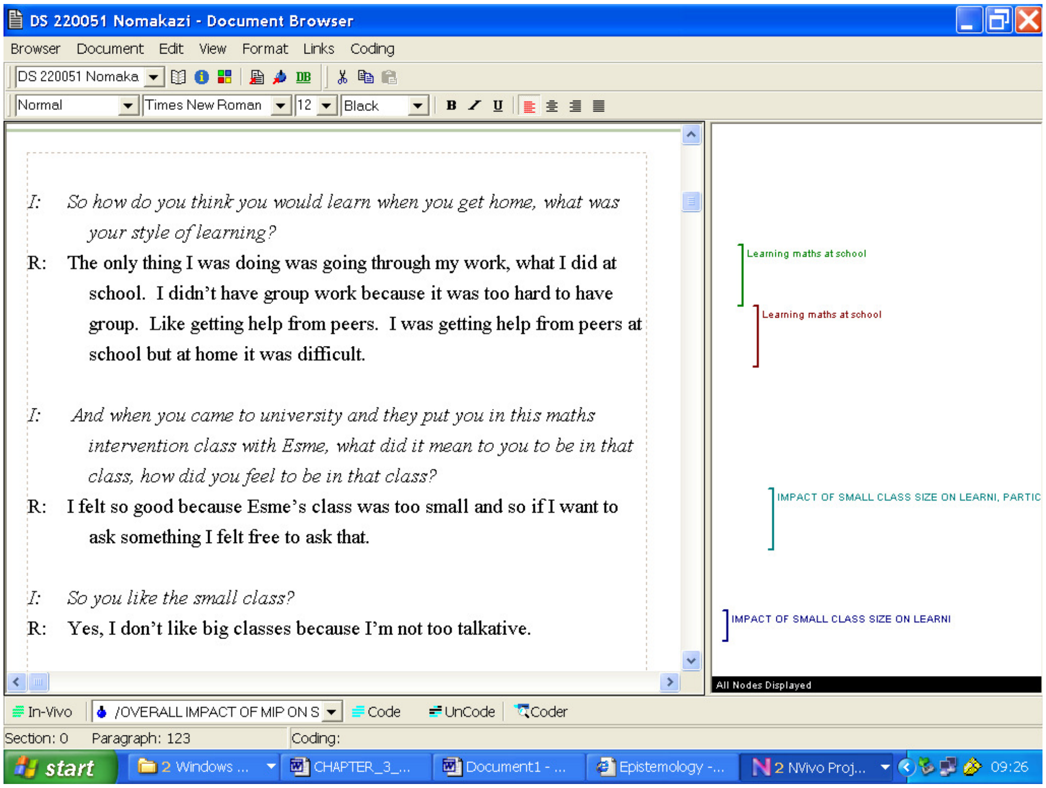
I would like to thank you for giving up some of your precious time to be interviewed for my master's study. Your time and valuable knowledge with regards to your experience in the MIP is greatly appreciated.

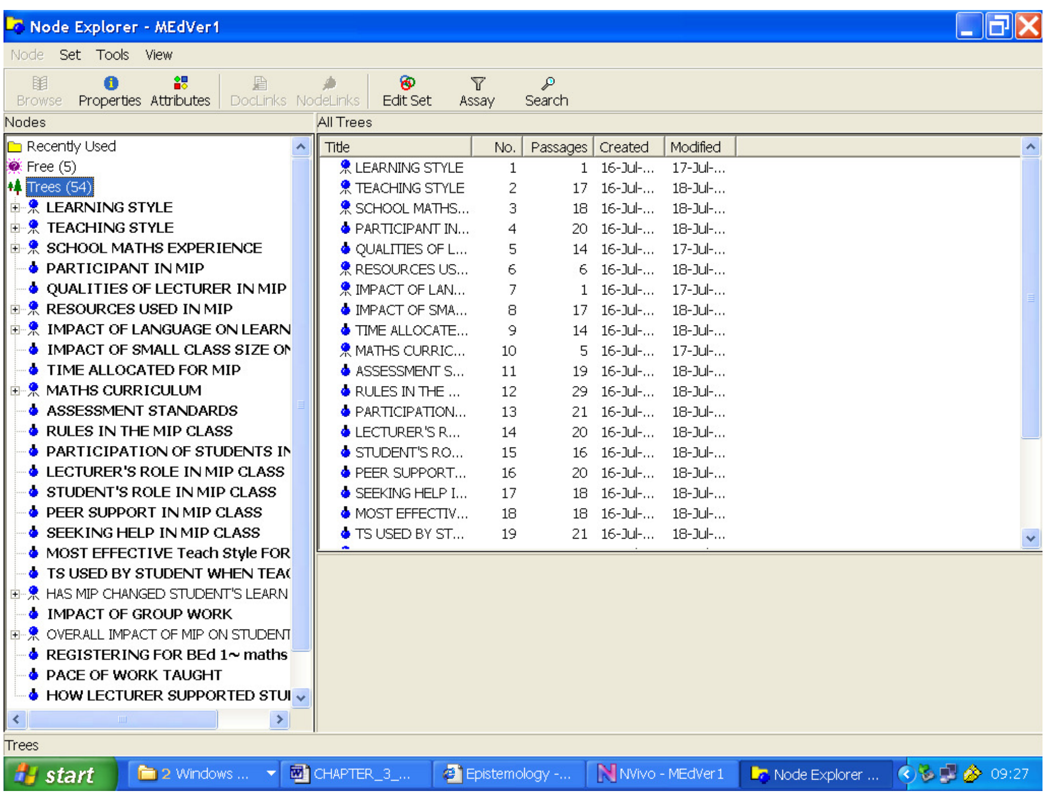
I would like to give you an undertaking, that your identity will be kept confidential and that your information and views would be recorded solely for the purpose of my study.

Yours Faithfully

Sue Pather
Researcher
Tel. 021 – 680 1586 / 084 689 8584

APPENDIX D: SCREENSHOTS OF CODING IN NVIVO





APPENDIX E: POST CODING SUMMARIES OF TRANSCRIPTS

<u>**INTERVIEWEE 1**</u>

Subject

I'm 21 years old, I went to Rustenberg High School. I did maths to matric, standard grade. Ichanged from mainstream maths as I was hoping to get more attention in the MIP class I was lagging behind in the mainstream maths class and I didn't like that so by being in MIP Lecturer 's class I thought I had a chance now to perform.

Learning Style

The way I knew maths is sort of mechanical, the teacher does an example, you do an example and that's how I learnt.

Language.

English was not a problem at all. I've always been taught in English.

Teaching Technique most effective for learning maths

When we used concrete things it was a good teaching teachnique.

Tech used when teaching:

The same, the concrete, but we have to use it because of the level the children are at the foundation phase.

Tools

We had concrete things to work with when it came to geometry. We could build with them and from there go on.

A lot of examples, repetition and exercises until you can do it in your sleep.

Worksheets, which was useful, these were from the internet.

We did group work in the beginning, depending on what section

small class size

The small class was good, she had time to go around and when someone was stuck so she would attend to that.

slow pace

The pace of lessons was just right. It wasn't too fast and it wasn't too slow. I think everyone was at the same pace. It was a regular pace.

Yes, the slow pace helped because we weren't just rushing through it to get the work done and having half the class not understand I don't think there's any point in that.

Division of Labour

Lecturer

To teach, to support, to empathise with us.

lecturer support

She will give us encouragement especially in the difficult parts and then she would have a trick to make it easier.

Student teacher

To get to a level where I'm confident in maths. That was my reason for being there.

Peers

I worked with my peers in group work and when I get stuck. When I needed help, I would first discuss it with the person next to me and if she couldn't help I would go to the lecturer.

Community

The small class environment was good, I liked the environment, the small classes and the attention.

We worked together as a class, so we were working with maybe geometry in group work, long division, and we would basically help each other.

I didn't mind the group work, it was actually helpful to see, because especially when you see how other people work, you can adopt their easier method, make less mistakes, so you pick up on little tricks.

I think the students in the class were very free to stop and ask questions, get her to explain things and she was also willing.

Object

Improve grades

1. Yes it has improved my grades, I'm passing. I'm actually doing well.

Attitude towards teaching maths

2. My attitude towards teaching maths is better. -Because throughout my school life maths hasn't been something I was able to do so I told myself maths was not for me. So now that I'm getting good grades and I'm understanding, I'm able to explain and help somebody. It feels good.

Rules

curriculum

I don't know where I'm going to use some of the things I'm doing because I'm in the foundation phase and I don't know what grade 3's are doing at the moment, but we're doing geometry and things like that. In school they do it on a basic level but not what we're doing.

Assessment

We have more tests than assignments, we have spot tests, she takes marks for her work and modular tests and that's a lot of work, which is not too cool.

I prefer more assignments, you can do an assignment if you were weak in a test if the test counts, what chance do you have of passing?

Implicit

It was normal university rules, she didn't say anything.

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APPENDIX E: POST CODING SUMMARIES OF TRANSCRIPTS

<u>INTERVIEWEE 2</u>

Subject

I'm 29 years old and I'm a Xhosa first language I did maths until matric and I failed because I had F standard grade.
I went to school in Eastern Cape, Thsongabasthu Secondary School.

Learning Style
Most of the time I had to practice and not practicing alone, practicing with peers so that helped me very much.

Language.
I have told you English is my second language so sometimes I struggled but because I have that background so it became more easier.

Teaching Technique most effective for learning maths
The actual making of the objects was the most effective teaching technique.

Tech used when teaching:
The actual object because if you do it you wont easily forget.

Tools

She asked questions, so that questioning technique was very good.
Most of the time she used papers.
Yes, worksheets for example, when she introduced shapes she gave us papers and asked us to do some shapes.
She gave us homework everyday

small class size
The small class size was very good

slow pace
The pace for me sometimes it was too slow and I get bored so sometimes I did skip the classes.

Division of Labour

Lecturer/ lecturer support
She was there to answer our questions.
The lecturer answered our questions and then she was trying by all means to support us if you don't understand or you got it wrong, she would just say you got it wrong or you were right here.

Student teacher
My role was to ask questions when I didn't understand anything.

Peers/peer support
I had to go to peers and ask when I had a language problem

Community

At first I didn't understand it. I thought that class was for the non-understanding ones but I found out that it was a very good class because there was only 8 of us and then we had a good chance to ask questions and to do groups. So it was helpful.
We felt free.
The lecturer answered our questions and then she was trying by all means to support us if you don't understand or you got it wrong, she would just say you got it wrong or you were right here.
In the class you had the opportunity to ask not the teacher only but the peers also so if you don't understand something you had to ask.

Object

Improve grades
1. Improving of grades. I told you earlier I had an F symbol, I improved because my mark was 61% so I was very grateful for that.

Collaboration
I found that working with peers is something new for me. I didn't do that before so I engaged myself with them now and that was more easier for me.

Attitude towards learning maths
3. attitude towards learning maths, I am looking forward to learning more maths now.
I think it's the way the lecturer did things for us that changed my attitude.

Motivation to teach
2. motivation to teach maths. I wasn't sure that when I chose maths as a subject that I would teach it but now I think that I can do it.

Confidence
The programme helped me to build me confidence in maths because I didn't have confidence in maths

Rules

Structure of lesson
First of all she asked questions to recap on the previous lessons so that helped us a lot because we did maths eleven years back and when you see a problem you can tell how you can do it now, so that questioning technique was very good.
It was also group work in class.
Yes, for instance, in my group we had to share the steps and if you don't understand we help each other.

Time
Time was very good

curriculum
It is good because that time when we did maths at high school we were just doing maths but now we are student teachers we know what the outcomes are, so it's good.

Explicit
She strictly mentioned that you have to be in the class, you have to attend and write tests.
What was important is that she gave us homework everyday so we had to do our homework.

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APPENDIX E: POST CODING SUMMARIES OF TRANSCRIPTS

INTERVIEWEE 3

Subject

I'm 19 years old
I don't have a matric maths qualification.
I have a grade 9 maths qualification.
I schooled at Sans Souci Girls High.
High school maths was basically the work gets done on the board, my maths teacher just gives you one example on the board and then you just had to deal with the exercises, it was very formal, she didn't walk around, the class became disruptive, the girls just started speaking and didn't bother, so obviously the concentration and the focus was gone out of the window because that teacher wasn't as attentive as this teacher in the intervention class.

Learning Style

the way I believe I learn is that I learnd with mind maps and sometimes just pure repetition, memorise things, nowadays I do that a lot because of time.

Language.

No, language was not a problem, English is my first language.

Teaching Technique most effective for learning maths

I think the concrete things definitely help me understand maths

Tech used when teaching:

I would definitely use concrete things first and then work more towards the abstract, she has been a very good example.

Tools

She used a lot of concrete things which helped everyone a lot, blocks and shapes and things.
10: She also used worksheets where you actually cut and paste for geometry?
15: she used the projector and worksheets
18: she gave us the worksheets that was usually how it worked but she never really used the board, she uses the projector more often in her classes.
65: I felt good in the beginning but then I got a little bit frustrated because I sometimes wanted to do the work on my own. She did have a lot of group work.

small class size

The class size made a positive impact, yes, I think it did. We were a few so we had a lot of individual attention.
28: I felt good because someone would actually listen to me when I had a problem.

slow pace

The pace was very nice. It was not too slow, not too fast. In the beginning she introduced what we were going to do. She made me understand.

Division of Labour

Lecturer

She helped us a lot, she guided us. She would teach us like the formula and then she would come around all the time. You would always see her walking around, checking to see if our answers were right, checking to see if we understand because there were some students who still never understood, so she would sit more with them but she would go around to everyone.

Student teacher

I just thought that I would have to be an attentive student and just pay attention and try to understand the work.

Peers

There actually was a lot of group work but there was group work in the class and homework was basically our individual work.
67: Yes, that was the nice thing about groupwork because sometimes I wouldn't understand then the person in my group would explain or I would explain to them, so we helped each other in the group because sometimes we wouldn't understand what the teacher is saying.
89: I would first seek help with a peer though and if we both still struggled we would ask her for help.

Community

When I was selected for the programme I was very excited to learn because MIP Lecturer made me feel very comfortable in the first session of our maths. She asked each one of us our own experience of maths and how we feel about it and she actually changed my perception of learning maths.
Very casual, relaxed. She made us very relaxed.
86: They helped me a lot. We all didn't understand some things and then she would notice that and then she would explain. If one or two of us didn't understand we would ask each other and help each other, so we were very supportive with each other.
118: It was a different experience and it was a very comfortable and happy to learn maths now.

Object

Improve grades

1. In improving my grades definitely and 2. my motivation to learn maths yes because I was always afraid to do maths because I thought I was stupid and I don't understand maths but she made me understand and feel comfortable.

Collaboration

4. Group work yes, I do enjoy but I think sometimes I think you should give a child a chance to work on their own.

Motivation to learn

2. my motivation to learn maths yes because I was always afraid to do maths because I thought I was stupid and I don't understand maths but she made me understand and feel comfortable. I'm definitely motivated to learn maths.

Attitude towards learning maths

She definitely changed my attitude towards maths because in high school it was a terrible experience, it wasn't nice.

Attitude towards teaching maths

3. When I teach maths in my own classes now I enjoy it.

Confidence to teach

5. Mainly it was my confidence in teaching maths and my attitude, a positive attitude towards maths in both teaching and learning of mathematics. My whole perception changed.

Learning concepts

learning mathematic concepts yes, and also the worksheets but I wasn't big on that.

Overall impression MIP

MIP definitely changed everything how I learn mathematics, I never thought of using concrete things. I didn't even use that in high school.

95: Yes, and also just practicing a lot, a lot of homework also helped.

105: My whole perception changed.

Rules

Structure of lesson

She tried to do so much group work.

40: The minute you came in, we got straight to work.

69: They didn't ask a lot of questions while she was teaching but when we would sit down and do the work then we would like say "ma'am can you come here please and help us with our work?" So there wasn't a lot of questioning while she was explaining the work and she didn't ask if there was any questions.

72: When we walked into the class, it's like immediately your books had to be out and we just started working from the word go.

74: It was first take out your homework. She checks if you did it and then we would mark the homework and then go on to new work. But, say for instance if it was a group activity then we would start with that immediately, that's why I say the two periods was not enough.

Time

The time, well I don't think it was enough though.

36: because we had a lot of homework then, which is fine. We didn't have a lot of class time because the periods were only 45 minutes.

curriculum

The content is worthwhile because it's things I obviously didn't do in matric maths and what I've learnt about geometry made me remember so it helped me a lot. The content was good, it covered everything like…

45: Yes, and she taught us the basics, like basic maths and she taught us basic multiplication , the basic functions of maths and that actually - because some of us struggled with our foundation of maths, so then it helped us later in the year to understand other concepts.

Assessment

Oh that was good, it helped me a lot, the spot tests really

Explicit

Yes, attendance was very important, if you were absent you would miss out on a lot of work, you really did and then you will have to catch up on the work and do extra homework, so that was the main rule being there in the class, otherwise any rules was just like be attentive, listen don't talk.

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<u>INTERVIEWEE 4</u>

Subject

I'm 25 years old
I did maths up to grade 9
my first language is Afrikaans
went school at Atlantis Secondary in Atlantis.
I was very afraid of algebra at school because I couldn't do that. I wasn't speaking in the class. I was always at the back in that class so that he could not see me.
I had to be open-minded and put a lot of effort in and be on the same level as the others because I finished my matric in 2000 and 1997 was the last I had mathematics.

Learning Style

I believe I learn from someone else, how that person make improvement and how I can improve on that.
Always from my notes. So at school I was looking for notes and learnt from that.

Language.

No, language was not actually a problem. At first I was very scared of the English because I had to learn in English now but MIP Lecturer is Afrikaans speaking as well so if I didn't understand the question, I would ask her it in Afrikaans then I would understand.

Teaching Technique

I think the problem solving with the objects was most effective for me.

Tech used when teaching:

The same techniques she was using. First let the learners solve the problem and ask then how did they come to that answer and then afterwards I will say how did I come to the answer, because there are different ways to get the answer.

Tools

Always when she starts a new topic she always bring in physical objects to work with so she did problem solving,
So if we do nets she gave us a box and then we had to open the box and then draw the lines around the box and then she would say now that is a net.
She used the overhead projector a lot board-writing as well.

small class size

Everyone gets a chance to give an opinion or an answer so we built a lot of self-confidence in the class.

slow pace

For me the pace was okay. It wasn't fast only that last… ,maybe she couldn't finish all the work so…but the pace was fine

Division of Labour

Lecturer

She was responsible for us to get the answers and also she walked from group to group, speak to the group how did they find the answer so that was a responsibility to see if everyone know how to solve a problem or do that specific sums.

lecturer support

She supported me very well and I can say that I passed with 88% and I felt very good. Because of a lot of questions I asked. I wasn't afraid to ask. She was open.

Student teacher

I had to work with her to improve in my maths.

Peers

Group work was fine because the people in the group we understand each other and we work well together and we have learnt a lot about someone's interpretation or someone's answer to a question, it's not the same as yours, so you get a broader understanding.

peer support

They worked well with me and we also studied together and if I didn't know how to do a problem they would also help me
First I check on their things (peers), if they didn't find an answer I will ask MIP Lecturer to help me.

Object

Improve grades

2. It improved my marks. I didn't want to teach maths that's the anxiety but now I want to teach maths yes.

motivation to learn

4. motivation to learn as well because I know the answers.

Collaboration

Because now I have a passion for maths. I feel comfortable. I think this is my strongest subject. Group work. because in school I didn't work in groups, we didn't get a chance to work in groups now I see it does work
it's better to speak to my peers than doing it alone.

confidence to teach

1. Confidence to teach mathematics.
Because I know now how to do mathematics. The content I understand so that is why I can give it to the children as well.

attitude towards teaching maths

I didn't want to teach maths that's the anxiety but now I want to teach maths yes

learning concepts

Problems all the time and also from notes as well.
Learning mathematic concepts: I still stick to the teaching method that I learnt from school.

Overall impression MIP

I never thought I would like maths, now I want to teach maths when I go to the schools. I've overcome that anxiety.

Rules

Structure of lesson

Always when she starts a new topic she always bring in physical objects to work with so she did problem solving,
Yes, we were put into group and we had to sit like that for the whole year so we did a lot of group work.
Yes, you can work on your own.

Time

Time was enough and she gave us a lot of homework and it gave us time to do that.

curriculum

It was very useful because when I went out to schools they also did the same thing, so I didn't learn stuff that I'm not going to use afterwards.

Assessments

It was fine. It was easy to pass because there was a lot of spot tests and it made learning much easier as well

Explicit

Yes, there was one specific rule where we had to do our homework and then she gave us 10 marks and that would also count for our final mark for the assessment.
Yes, to be in class every day.

Community

Like I said we were a small class and that's why we know each other in the class and we felt self-confident to speak because it wasn't a rush. She gave everyone a chance to speak.

APPENDIX E: POST CODING SUMMARIES OF TRANSCRIPTS

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INTERVIEWEE 5

Subject

I stay in Strand, I have three kids and a husband. I stay with my family, I'm 40 years age, I left the school at 1992. I last doing maths at standard 7, My first language is Xhosa, My last school is at P.E., I drop maths when I went to standard 8 because I met a teacher who didn't explain properly so I was losing marks every time so I was so scared not to make it to standard 10,

Learning Style

My style of learning is that I have to concentrate what I'm doing.

If I'm doing this maths I have to practice it everyday, everyday

I have to make sure that everyday I practice so that I can get use of it.

Language.

Not really had a tutor being taught in english was not a major problem.

The difference between Colleen(her tutor)and her (lecturer)is because Colleen was speak softly and she take her time and make some more example for me but my lecturer havn't got the time because have to rush to other class and the other kids were quickly thinking so I'm slow so Colleen she's looking after me only.

Teaching Technique most effective for learning maths

When she do more examples all the time it helps me understand maths.

Tech. used when teaching:

I will use things that the kids use in everyday life, like objects, like shapes in maths. I will take things that the kids use at home like coke tins and ice cream cones. There are so many things.

Tools

She used photocopies, worksheets.

homework

she write on the board

When she works on the board, I don't understand nothing like I don't know what is going on there, but when she gave us the worksheet cos sometimes the English confuse me then I need some time to read for myself, take my time, so that I can understand what does this mean.

small class size

The small class really helped a lot.

I'm feeling good there. It's fine for me with my MIP lecturer.

slow pace

She give us too much work, a lot of homework everyday.

Division of Labour

Lecturer

She did her work. She ask us if we understand and she make sure that we understand and she ask if we don't understand we can raise our hands, so that she can come and explain for us. Shame, she make sure we understand although we so scared.

lecturer support

When I don't understand I did put my hand up and maybe when she is in a rush I told her to talk slowly because I didn't understand the question quite well, so she go back to that question and explain

Student teacher

Object

Improve grades

my grade improved

Collaboration

Attitude towards learning maths

1. Attitude towards learning maths.

Because last year I was so scared really, too much, but this year I love it very much and I want to learn. It was just me that changed my attitude because it is because I know it now. I understand it now.

Motivation to learn.

2. I feel happy and I'm looking forward to learn maths. Now I love it now.

Confidence to teach

I'm still nervous to teach it.

Maybe it's because of my language, because at school I have to introduce it in English, so that is why.

Overall impression MIP

The MIP helped me very much. I improved.

Yes, it has changed the way I learn.

It makes me have more interest in maths every day, cos I don't want to be ashamed in that class. I like maths very much now because I know where I am with it.

Rules

Structure of lesson

She give us too much work, a lot of homework everyday.

We do the individual work most if the time cos when she gave us homework then the following day she's going to do it with us, almost all the time she gave us individual task to do.

Time

Two periods is enough.

curriculum

It was very good topics.

Assessment

Yes, it's very good to give us the spot tests because it's where I know where I am now like every time she tests us.

Sometimes she gives us homework then I didn't do the homework so she come to us and ask 'did you do your homework?' and you say yes even if you didn't do the homework, so when she give the tests it's when I know where I am.

Explicit

You have to attend every day, every day.

Community

We blacks are scared to participate in class but we try because we scared maybe we are doing the wrong examples or maybe we are not doing well.

we don't talk too much

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INTERVIEWEE 6

Subject

I'm 24 years old.

I did maths in standard grade

Zewelwe Senior Secondary School at Eastern Cape.

My first language is Xhosa and my second language is English.

Learning Style

The only thing I was doing was going through my work,

Language.

As I said, English is my second language so I didn't have that much problem in her language because I understood what she was saying. If I don't understand I just ask. The language was good for me, it was okay.

Teaching Technique most effective for learning maths

Now I know that if you are teaching maths, don't use one method, use different methods, if you use mathematical methods use the practical way so that if I don't understand the mathematical problem, I can understand it practically.

Tech used when teaching:

First I must involve the students. I mustn't tell them everything.

For instance, I will give them cards and they will fit in the cards and see that if you add two quarter then you will get a half.

Tools

When she was teaching us, he always used different methods,

22: when we are doing subtraction or maybe addition she will give us a sum and ask us which method can we use to solve this problem.

22: MIP Lecturer told us that is not the only method you can use, there are other different methods you can use to get the answer.

25: when we do shapes and 3D objects we cut the papers, we cut the cardboards to get the shape.

28: The chalk board. She was not hesitating to use this chalk board. The work sheets.

34: Yes, I do like it because if you use the worksheet, you just look at the worksheet, you don't look at the board. It was good to use the board, but it's also good to use the worksheet.

small class size

I felt so good because MIP Lecturer 's class was too small and so if I want to ask something I felt free to ask that.

19: Yes, I don't like big classes because I'm not too talkative.

43: The number of students were not too much, we were few so I think the class was good, because if it was too small, you feel free to do whatever you want to do, if it is ok.

slow pace

She was not too fast she was more like slowly because our class was I don't know, it was like a second level

123: I was in MIP Lecturer 's class, it was good for me being there because MIP Lecturer was going at a slow pace.

Division of Labour

Lecturer

She was helping us all the time. She was making sure that we understand the work she was doing

lecturer support

If you have a problem, you ask the lecturer and then she helps you or if she doesn't have too much time for you, she advised you to get some help from another person or ask somebody in the class to help you.

Student teacher

I have to make my work. I have to participate in class.

peer support

Yes they are supportive. If you have a problem they were willing to help you all the time.

I would ask MIP Lecturer to help me but first I ask my peers to help me before I go to MIP Lecturer .

Object

Improve grades

I think number one improving the grades,

As I said in grade 12 I didn't get a good symbol.

Last year I had good marks.

Collaboration

Here you work with people with different opinions and views and that is a motivation for me.

attitude towards learning maths

I like maths.

motivation to learn

When I do maths now I work with different

people, it's not like in high school where you have to be on your own and do your work.
motivation to teach
motivation to teach mathematics, yes.
Confidence to teach
The important one I think is confidence to teach maths.
The reason why is that if you want to teach maths you have to be confident. If you know what you are going to do you will feel more confident so for me to teach maths, MIP Lecturer taught me in a good way. He built the confidence inside me. I like maths even before but I didn't have that much confidence to teach it but now I have.
Overall impression MIP
I didn't get that chance to practice all the time, but now I know that I have to practice all the time because the more I practice the more I get.

Rules

Time
I won't complain about two periods because we've got too much work to do so I don't think I can say this two periods were too few
curriculum
so that syllabus was good for me although I didn't finish the syllabus last year.
Assessment
Spot test, modular test. We had too much spot test and that was helping us a lot because before you write the modular test you have to do the spot test and to prepare yourself.
Implicit
Not really, but we have to come early and we have to participate.

Community

I think lot of individual work but also group work. For instance, if you don't understand something you will go to some group because we were using a round table. If you have a problem you just ask next door.
82: They felt free because you can talk to MIP Lecturer any time. Our class was small, we knew each other so you can go to anybody around the class and ask.

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<u>INTERVIEWEE 7</u>

Subject

I am 22 years old.
I am a Moslem
I was at a Islamic High School named Dawaar Islaam
Learning Style
Memorizing, when we learnt the Koran we were asked to memorize all work
Language.
at home it's English,
Being taught in English was not a problem at all. It was quite fine.
Teaching Technique most effective for learning maths
answering questions. She will maybe do a sum on the board and then she'll do it and say 'who has a problem to understand it?' I think we were willing to raise our hand and she will explain it.
Tech used when teaching:
you know, I was teaching maths when we were at teaching practice and I really enjoyed myself because I actually applied the same technique that MIP Lecturer is doing without even knowing
I wasn't only teaching a sum on the board, but I will always ask and I see it worked.
I applied that and that works for me. Asking questions, 'do you understand, what don't you understand'?

Tools

She used like worksheets
She used the overhead projector most of the time.
The board
small class size
The class size I never actually had a problem with it. I was just concentrating on my work and my section of the work.
47: Yes, I think it will definitely have a positive impact, the reason being,
51: we can get more attention from the lecturer, she can spend more time with us individually that's now the positive that I can say. Individually will assist us a lot, honestly.
slow pace
Oh yes, the pace of work is fine you know. MIP Lecturer has a moderate system in the sense of she won't go too fast and she also won;t go too slow - in-between. She considers everybody

Division of Labour

Lecturer
MIP Lecturer is a person she's willing to help you know
lecturer support
If I ask MIP Lecturer , I'm struggling with something, she's always able to help me.
She just wanted to help us you know. She maybe thought ok these guys want to learn so lets see what I can do.
She will always consider everybody. She will not just take my part. She will never first go back and tell 'ok I'll come back to you tomorrow. If she don't know something 'I'll find out' you know but we all come down to a mutual agreement eventually.

Student teacher
I enjoyed myself, I learnt a lot and it really helped me.
I will basically go to the lecturer. I will state my case and I will ask her and tell 'her miss or sir 'I have a problem and this is my problem.'
Peers
because you always learn from somebody else, if that person knows you can pick up.
peer support
they were very supportive. I haven't met anyone in my class that said 'no, go away' or 'I can't help you.'
If I have a problem or if I struggle with something then other people are also willing to help and say do like this or do like that. That also helped me a lot.

Object

Improve grades
Oh yes definitely. I mean my marks improved gradually basically. I know it and I've seen it. Not to the best of the best but I saw an improvement after each test
Collaboration
3. collaboration and group work, that did help me, getting knowledge of other people helping me.
attitude towards teaching maths
My attitude towards teaching maths. My whole attitude towards maths has changed positively not negatively.
Confidence
This one definitely.1. It has given me confidence. I was always afraid how to, I cant, I'm too stupid, but I feel totally different now
Overall impression MIP
I'm thankful for that maths intervention session you know.
I think basically the way it changed me is all the group work and all the activities that I was exposed to and how to do it. It has changed me to an extent because I used to study maths parrot fashion which now I realise it's impossible.
But it really helped me because now I understand you must understand the work first, how it works and that, so it helped me to a certain extent basically.
146: One, asking questions - the way she asked questions, number two the group work and number three you can ask any time any thing if you have a problem. That's basically it. Don't feel shy, don't be scared, don't think you're stupid.
150: MIP Lecturer 's class we always used to say last year we are the special group because we work slow because we're special and I don't have a problem with it and I am thankful for that class.

Rules

Structure of lesson
MIP Lecturer will explain something to you then she put on the board she'll give an example, etc and you must work it out. Then she walks around and if you have a problem you ask her, that's MIP Lecturer , that's the way she teach. She's a person she will help you. You just raise your hand and she will be there.
Sometimes there were group work and sometimes individual. Like when we working with blocks and stuff she'll maybe say we at a round table like this 'ok you guys work together', there were group work sometimes.
Time
Yes, it was fine for me.
curriculum
I think the content was nice you know. It gives you a broad understanding of mathematics in general.
Implicit
in the maths class the attention is always there. Maths is something you must understand, so I think the respect and behaviour is there,

Community

I think they enjoyed participating in class. Yes all of us enjoyed it. There was interaction between us you know like I said we could learn from each other and stuff like that. If you know something you can tell me and we can help each other.
Everybody was free to say whatever they please.
Nobody was laughing at you when you did something wrong, like this guy is stupid, you know how children are at school? It wasn't like that in our class last year. You can be the oldest guy, the youngest guy, you can laugh but no one will take it like this guy is stupid, we will all laugh together.

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<u>INTERVIEWEE 8</u>
Subject

I'm 20 years old
I went up to grade 9 maths.
I went to Cambridge College.
My first language is English
Learning Style
By doing things practical and understanding and having a good teacher
Language.
The language was fine, I understand it well.

APPENDIX E: POST CODING SUMMARIES OF TRANSCRIPTS

Teaching Technique most effective for learning maths
I think the making of the objects was effective for me to learn maths
Tech used when teaching:
I would probably use group work, and then making the shapes themselves as well to see how it looks, obviously with me explaining to them how to do it.
I would use groupwork so that if someone doesn't understand, everyone understands it a different way so that they can help each other understand the concept.

Tools

There was a lot of interaction and we used the overhead as well
12: making use of resources to go with the maths that we were learning it was very nice and interactive
15: work in groups.
small class size
The small class size made me feel relaxed and more confident to be in the class, understand better.
slow pace
For me it was a bit slow.
28: Because I understood it quicker that the rest so I would like help them but then she would give me more work to keep me busy.

Division of Labour

Lecturer
I think her role was to teach us the maths concepts and stuff and she done it well. She was very friendly and made sure we understood. She would come to our groups and discuss what we don't understand and what we do.
lecturer support
She was very positive and she was nice and friendly.
67: We would just lift up our hands and MIP Lecturer would come to us and explain the problem what we have. We just tell her if we don't understand and she will help us.
71: If I had a problem I preferred going to MIP Lecturer to explain.
Student teacher
I worked by myself. If my friends needed help I would work with them and explain how I understood it.
58: To learn, understand and make meaning.
Peers
I wasn't keen on groupwork because I like to do my maths alone because somethings you have to think about and understand and with people talking the whole time I can't really pay attention to what I'm doing. I get distracted very quick.
peer support
supported us well. I think group work worked well for them.

Community

It was mainly our choice to work in groups but you could work individually as well. If you didn't understand, you could work in groups or ask the teacher.
50: We were all very interactive and confident. We weren't shy or scared to make a mistake. If we made a mistake we would all correct it.
90: My positive attitude is probably due to the friendly environment of the maths and it's relaxed and if you make a mistake it's ok. It's not like somebody is gonna laugh at you.
111: I was relaxed when I saw my friends and stuff and they didn't understand maths that well when we started and it was just smooth and she would explain and help us with stuff we didn't understand and it was ok to make a mistake.

Object

Improve grades
1. Well, my grades have improved. That is because I understood what I was doing, I could study
Collaboration
3. Group work: I wasn't really keen on because I don't like group work for maths. I prefer working on my own, but I saw how it has helped the other students.
Motivation to learn
2. MIP has made me more positive towards learning maths and I understand it better.
It has made me more enthusiastic to learn and want to understand maths instead of just wanting to give up.
attitude towards teaching maths
Learning concepts
4. learning of the concepts I like the way it was taught, we were discussing it and doing the hands-on.
Confidence
I have more confidence, I have a positive attitude towards mathematics now.
Overall impression MIP
This programme helped me a lot, I 'm glad I was in that class because it was small numbers.
74: MIP has made me more positive towards learning maths and I understand it better.
101: Yes I would recomment the MIP, especially to the ones that are negative or not feeling confident about maths.
103: I was scared of maths when I first walked into this place, I didn't want to do it.

Rules

Time

Time, yes, that was sufficient.

curriculum

I think we covered everything in depth and we understood, she made sure everyone understood before we move on. The content was covered.

Assessment

I liked that, we had spot tests and modular tests.

Explicit

Only to do our homework and to make sure that we understand when we came to class the next day.

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INTERVIEWEE 9

Subject

I'm a B. Ed student, I'm at the CPUT.
My first language is Afrikaans.
I went to an Afrikaans medium school Wolsely Secondary School.
I think I developed maths anxiety because I wanted to go study law but unfortunately I had to take maths. I did take maths but then have to drop it grade 12.
I think the problem was actually my teacher, because you know he was kind of too advanced, it's my opinion I think he was too advanced about us the learners. And he was expecting us the learners to know what he knows.
My school teacher's technique is just give us homework and the next day he call you to go do the maths on the board and he doesn't really explain to you the mistakes that you have mad in the problem and it affect me because later I become very anxious because he is going to call me to go to the board and what if mine is wrong.

Learning Style

I think that in school I learnt by doing repetition.

Language.

With MIP Lecturer if I don't understand something in English then I can ask her in Afrikaans and she will explain it into Afrikaans but with Lecturer X she don't understand.

Teaching Technique most effective for learning maths

I think the one where she brings the real-life situations into the mathematics was most effective for my understanding.
We have to build the geometry shapes with real-life materials.

Tech used when teaching:

I've learnt from MIP Lecturer so I would use her methods.
Where she's making examples of real-life situations and relate it into mathematics

Tools

MIP Lecturer used lot of examples, real-life examples.
On the board for instance when she's talking about something it seems that we're taking too long to understand what she's talking about then she will go up on the board and write examples for us so that we can relate that into the maths work that she's doing.
She used a lot of old exam papers for us to work out and it really helped.
She also gave us the questions we must do it on our own at home then when we get back to her then she will give us the answers.
She used the worksheets.

small class size

The small class size had a really positive influence because now we are small and we're getting individual attention from MIP Lecturer . When she gave us some work she will come and walk around and look at your work and say, "there you made a mistake." And talk it through really.

slow pace

Slower pace of work was really a good thing because she is making a lot of time to make us understand that section before moving on to the next one.

Division of Labour

Lecturer/ lecturer support

She was there to help us through the syllabus and she really did a good job. I can see she's always on top of it, she coped very much.
-Like I said, when you were busy doing your work she would look around and see whether you made a mistake, she will talk you through that mistake.
-Sometimes she will ask you to do it on the board for the rest of the class to see and also help you with mistakes and afterwards she said we can come to her office if we work on our own at home and don't understand we can call her and come to her office.

Student teacher

To do my work, the homework and just understand the work so that it's beneficial for me at the end.
-In class I will raise my hand and say to MIP Lecturer I don't understand

Peers/ peer support

The class did support me. I think there it's a matter of like the other class would say we are the dummies so we stand by each other. If I don't know how to do this solution and a other person she will come and explain everything or that person will explain what she knows, We really worked together.

Object

Improve grades
3. Improving grades yes. In my first module tests in Lecturer X's class my marks were disastrous but after that when I went to MIP Lecturer 's class I passed all my spot tests also the module tests, I think it was 65 % and the exams also and I think if I were in MIP Lecturer 's class I would have done much better

Motivation to learn mathematics
1**.**I think it was from my previous experience from my teacher from high school, because I really didn't want to go into mathematics because for me it was just big words but now with MIP Lecturer she explained also she will explain every word like methodology of mathematics then she will explain that to you and that helped a lot. Now I know what that word means and I know what that stands for and so on.

Collaboration
4. Collaboration group work because there in her class I became more comfortable in working in groups because now I understood what is going on and I really enjoy that group work.

Attitude towards learning maths
But with MIP Lecturer I make time for my mathematics and I want to know everything.

Attitude towards teaching maths
Attitude towards teaching mathematics. When we went on teching prac last year when Anna Paula was there to crit me, I did a numeracy for her and everyday I was doing numeracy. In the beginning I was not going to do mathematics but it really changed and attitude towards learning mathematics also changed because I just thought to myself that I want to become a better teacher for the children where it concerns mathematics because it also begins with the teacher, how the teacher is giving maths to the chidren and sometimes in my case the teacher doesn't really help the children to understand, they just give the work because the children had to do it and so they don't really care if the children understand it and whether they don't.

Confidence
In class I will raise my hand and say to MIP Lecturer I don't understand, because I feel comfortable asking.

Overall impression MIP
Yes the MIP, it really changed my whole point of view of mathematics because when I think back to that week that we had to come in, I think if I was in mainstream maths class then I don't know if I would have come in for that week because for me I really learnt a lot in that week and the lecturer I think she just give me that comfortable feeling.

Rules

Time
It was a bit few, the time yes because of that we had to do that catch up week.

curriculum
Well, in the beginning I thought now why had we to do that because we are not going to do that with our children but that is where I think that is numeracy coming in because numeracy is you doing what you doing with the children and maths is for you own, so it's good

Assessment
We're writing a lot of spot tests in our class and two modular tests and the exams. I think it's suitable

Explicit
She also gave us the attendance mark.

Implicit
She didn't give us any rules.

Community

The class felt free yes really because I also like to join to ask questions and join the discussions in class.

105: She made us sit everywhere we want to sit as long as we're comfortable and can see her properly.

107: informal.

136: I think maybe it's the way she puts herself in the students' shoes. You would say that she's like one of the students, she want to get us doing the work. She will say that "I don't know, don't you have a solution?, she will do that and she gives you the feeling that you can do that. MIP Lecturer made us feel comfortable.

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<u>**INTERVIEWEE 10**</u>

Subject

I'm 25, I did maths at high school till grade 12 on standard grade. My first language is English. I went to Wynberg Girls High.

The maths teacher that I had she was very good at maths but I don't think that she taught the subject very well. It was mainly just going through the text book, doing exercises for the day. It would be 5 minutes of teaching and 55 minutes of socializing with the learners.

Learning Style
I think that I learn maths very practically instead of - you wont be able to teach me just showing something on the board.

5: You have to give me real-life examples on how it's going to work, so I guess I learn very slowly there.

Language.
Not for me because my first language is English.

Teaching Technique most effective for learning maths
more practical work per module.

Tech used when teaching:
I definitely learnt this from MIP Lecturer , but it was individual work with the learners and I would explain things practically with them, using real-life examples.
So I think a lot of the way MIP Lecturer taught was modeling what could be done in classes.

Tools

There were real-life examples that were being used in the class as compared to the regular class
8: she would use different examples to get the concept across.
12: there was board work of course but there was lots of practical examples as well.
17: there was lots and lots of worksheets, but your worksheets weren't your regular type of workheets. It was fairly interactive types of worksheets.
122: we would have more practice and more discussion about it as well, there was definitely lots of discussion in our class.
small class size
the small class size was good because there was more time to get it right with the whole class 'cos I don't think we were more than 12 learners in the class.
slow pace
In MIP Lecturer 's class I felt that I shone through because she was going slowly and she wouldn't go on until everybody knew what was happening so she would use different examples to explain the problem.
26: she would speak slower and she would make sure that everybody understood the work that was coming out of her mouth because there were third language English students in the class that wouldn't understand and because some of them hadn't learnt in English before, the concepts were a bit difficult to understand in English, so she would explain it in different ways so that they can understand.
32: it was an ideal pace. And because I was used to the fast pace so I caught on a little quicker than some of the other students, so it gave me more revision time, so it was also in my favour.

Community

We can always work with other people and always ask and the class was fairly interactive.
63: It was informal yet she wouldn't let it go out of hand. It was fairly maths based.
81: everyone felt confident enough to participate
81: In Lecturer X's class you had the bright spark group and then others would just fall by the wayside but I think that people understood it MIP Lecturer 's class that we're not here because we're brighter that anyone or that we're dummer than anyone else. There was no such thing as a stupid question because if you didn't understand you knew that you could just ask and she would go through it or someone would go through it with you. So people participated, there was no problem with that.

Division of Labour

Lecturer
Some lessons she would be a teacher, especially with the introductory lessons and some lessons she would be a facilitator.
86: I think her function was like more as a tutor.
108: Yes, definitely because I felt that was her role as well, if you needed help you should ask.
lecturer support
She never ignored anybody. She spent time with those that needed extra time.
Student teacher
Well, I chose to be in that class though because I felt that I could get a better understanding of what was going on in that class
106: I'd first ask one of the other people if they understood the work and sometimes it's ok to get an explanation from other students but sometimes there was a different way of understanding something so that is why I would then go to MIP Lecturer .
Peers
like with me it was nice that I could learn from other people and then other people could learn from me. So if there was a sum that I didn't know how to do and someone else knew how to do, we wouldn't give the answers 'cos that would defeat the purpose, it was more about showing the how something works or going back to basics.
99: If there was any understanding with my problem of maths there was a few people I would consult and they would consult me if they had a few problems as well, so there was always support.
peer support:
I didn't know how the class worked when I first came there people were very eager to help, they would without me asking say 'do you have this note, do you have that note?

Rules

Structure of lesson
I guess she would see what you understand and then she would latch onto that. A lot of what she used would be what we would be able to use in class as well.
41: We would come in and let's just say we were doing something new, we would revise a little of what had gone before and then she would just introduce the topic by just giving a little sentence or two and then give a little sums

or examples of how to do the stuff. Prime numbers for example and products or something like that. So she would highlight to you what the prime numbers are and …
43: what is a prime number for example and then making sure that everyone understands what a prime number is and then she would give you a worksheet which would also be interactive and there was never a case of individual work, you were open to work with a friend or learn from each other
Time
I think that in the 1st year it should also be maybe 3 times per week.
curriculum
I thought some of it was fun. The first section that we did, the first semester was very much what we would use at school and then the section semester was maths, like learning for ourselves
Assessment
the assessment I thought it was fair
Explicit
We were allowed to interact with each other as long as it was to help each other with maths.
Implicit
She required us to have a book which I thought was important because she would go around if you didn't have a book then she would comment and say 'I don't know how you're going to study'.
61: I think that we just participated in class and that we did our homework so that she's not standing there blabbing just for nothing.

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<u>INTERVIEWEE 11</u>
Subject
I'm 20 years old, I did maths up to matric
My first language is English, I attended Rocklands High.
The maths teacher was like the Deputy Principal and he was never in class and we were split in to higher grade and standard grade and he had to be on both sides and half the time he was never in the higher grade class (I was higher grade)
my maths really went down.
Learning Style
I learn through repitition and constant practice all the time.
Language.
language was not a problem.
Teaching Technique
a lot of repetition was effective for understanding maths. And the pace.
Tech used when teaching:
In the foundation phase I would probably use a lot of concrete, hands-on and as well as a lot of repetition.

Tools
A lot of hands on
she would let us make the actual shapes and show us how it looks
there was a lot of concrete, hand-on things.
she explained it in such a way that it was understood
we practiced it a lot and there was a lot of homework.
Overhead projectors
actual shapes
she did use the board and worksheets.
small class size
There was few people so I felt that I could say that I didn't understand, whereas in a big class I felt like I can't ask because everyone's watching so it did have a big impact in a good way.
slow pace
Sometimes I felt because I did maths up to matric and sometimes I felt that I know it already so maybe then it was a bit slow,
but there were times I didn't understand things and I felt that the pace was good at my level.

Division of Labour
Lecturer
We were all comfortable. I was comfortable because she wasn't the type of person if you got something wrong or you didn't understand she was patient, she would do it over and over and over again. After a while you say that you do understand even though you don't, but with her I felt I could say I still don't understand and she would do it again and again.
we can actually ask her when we don't understand and she would explain
To see that everyone understand, understood what was going on.
Student teacher
Do our homework and do the work she asked us to do.
She would give individual attention and she would see that you're uncomfortable. She would ask if everyone understood and you would have the odd look that says yes but on the faces it says 'oh no' and she would go and sit with them.
Peers
There was a lot of group work. I felt that it was good because sometimes I didn't know certain things when she explained it but when I had a peer telling me in a different way I felt that 'ok now I do understand', because she was saying it in a different way.
peer support
We'd have a lot of discussions, they would

explain. I had a habit of saying I don't understand and they would say 'ok, this is how you do it' Firstly I would ask my peers and then if they don't understand themselves then we'd go to the lecturer

Community

It was a comfortable environment, completely.

Object

Improve grades

1. Improved marks, changed drastically.

confidence to teach

I'm still a bit afraid to teach maths.
Mmm, in terms of teaching, the MIP hasn't changed my confidence to teach.

Motivation to teach maths

Still nervous, very nervous

Overall impression MIP

at first I though I was so stupid, how can I be here and then afterwards I thought it's actually an advantage to myself being in the MIP because had I been in that other class, I probably would have failed and being in the intervention class, I felt my maths had improved and I understand it much better that what I understood it in high school.
It's just now in this class it's at a lower pace so I could actually deal with that whereas at high school it was faster.

Attitude towards learning maths

2. Attitude towards learning mathematics because I understand so now I want to go for my work
My attitude changed because of the way in which the maths was taught to me. Maybe it wasn't in the way it was taught but the lecturer herself. I felt comfortable to ask questions or to say that I don't understand.

Confidence

That programme is fine because I have confidence in maths now

Rules

Structure of lesson

worksheets were fine it was set in a way where it starts off easy and then it got more complicated. Every time we got her we got homework and the next period we saw her we went through it and any problems we may have had.
There was a lot of group work, we sat in groups even when the class set-up wasn't in a group set-up, she would tell us to turn the tables and discuss and actually she would tell us she doesn't want us to work on our own, we must work with someone and explain and talk about it, the work that we're actually doing

Time

we got her twice. And it wasn't a lot of time with her but because we got so much work and it would fall over a space of a week so that every day we'd have to work on it.

curriculum

Sometimes I felt it wasn't relevant to foundation phase because I' thinking you're not going to teach about you do actually in a indirect way, you do bring it in but it was good.

Assessments

We wrote tests, a lot of spot tests which means that we constantly had to be prepared for a test. I feel that was good because then I have to go home and go over my work because I could get a test any time

Explicit

She really expected us to do our work and we'd actually get marks for our homework
when we were present in class she never let us sign or tick, she actually gave us a mark for that which is good because now you want to go to class because you gonna get a mark.

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Cape Peninsula
University of Technology

SUBJECT GUIDE 2006

FACULTY:	**Education, Mowbray campus**
DEPARTMENT:	**General Education & Training (GET)**
COURSE:	**BEd GET Foundation Phase**
	BEd GET Intermediate and Senior
Phase	
SUBJECT:	**INTRODUCTION TO MATHEMATICS**

PURPOSE OF THE COURSE

To introduce and develop an understanding of the basic mathematics needed for teaching in the GET - Intermediate phase.

SUBJECT COURSE OUTCOMES

- To develop students conceptual understanding of specific topics in the primary school
  curriculum at the elementary level: number, geometry, measurement and data-handling
- To know and understand the mathematics content and skills prescribed by the national curriculum
- To assist students to understand the difference between procedural and conceptual understanding of mathematics
- To prepare mathematics education students that feel confident and competent to teach
  mathematics in the primary school
- To provide a non-threatening environment for the learning of Mathematics and to
  help equip student to create a rich and creative learning environment in their classrooms

APPENDIX F: SUBJECT GUIDE – INTRODUCTION TO MATHEMATICS

PROGRAMME

Topic/Module/Unit
1. Number and Number Patterns 2. Geometry 3. Number, No. history and bases 4. Measurement 5. Data Handling

ASSESSMENT

This an **examination subject**, which means that the year mark and the examination mark are used to determine the final mark. The relative weights are 50:50. The year mark is determined by means of 3 tests, 1 assignment and class tasks (homework, spot tests, investigations). The examination mark is obtained from the exam written during October or November.

ASSESSMENT	DATE	WEIGHTING
TEST 1	30 March	10%
TEST 2	22 June	10%
TEST 3	28 September	10%
ASSIGNMENT	3 September	5%
CLASS TASKS	Continuous	15%
EXAMINATION	Oct/Nov	50%

To pass the subject, you need to obtain a **final mark** of at least 50%. This mark is compiled as follows:

$$\text{Final mark} = \frac{\text{Year mark + exam mark}}{2}$$

If your final mark is between 45% and 49% you qualify for a re-assessment. Names of such students will be posted on the notice board after the exams. It is **your** responsibility to consult the notice board to determine whether you qualify for a re-assessment.

APPENDIX F: SUBJECT GUIDE – INTRODUCTION TO MATHEMATICS

SUBJECT CONTENT

1. Number (LO1: Number, operations and relationships)

….. the student should be able to

- Identify different types of numbers using the number system
- Calculate factors, multiples, prime factors, square and cube roots of numbers
- Recognise figurate, cube, fibonacci, prime and composite numbers
- Determine the factors of whole numbers using divisibility rules
- Demonstrate understanding of the laws of operations
- Use a variety of approaches to solve computational problems

2. Number patterns (LO2: ….)

….. the student should be able to

- Recognize a variety of numerical and geometrical patterns
- Complete and describe numerical and geometrical patterns
- Compile table and flow diagrams for different number patterns
- Find the function rule for a given pattern

3. Geometry (LO3:….)

….. the student should be able to

- Identify 2D and 3D geometric objects
- Analyse the properties of 3D geometric objects
- Construct and draw nets of 3D shapes
- Draw floor plans of 3D figures
- Recognize and classify Platonic solids

4. Measurement (LO4:….)

….. the student should be able to

- Demonstrate knowledge of key elements of measurement
- Measure using simple instruments
- Use measurements in various contexts, including sizes of clothes and shoes
- Understand and use standard units of measure
- Define relationships and convert between different units of measure
- Calculate the perimeter and area of polygons and circles

5. Data Handling (LO5:…..)

….. the student should be able to

- Identify situations for investigation
- Read and interpret numerical information in a range of contexts, specially data represented in the media
- Read, represent, organise, and interpret information in bar graphs, pie graphs, histograms, frequency tables, line graphs and scatter plots
- Critically evaluate different forms of representations
- Calculate, use and interpret mean, median, mode and range appropriately
- Recognise and assess when data has been misrepresented
- Recognise trends in data from graphs and tables
- Find correlation between two sets of information

METHODOLOGY AND TIME MANAGEMENT

1. Teaching method

Instruction will include a combination of lectures, practicals, individual and group work,

with ample opportunity for self-activity and discussion.

2. Attendance and Punctuality

One hundred percent attendance is required from you. The nature of the subject, and the way in which we present it, is such that attendance of **ALL** students is required. Some year marks may be allocated for attendance. In case of illness or any valid reason, absence **MUST** be explained to the lecturer as soon as you are back in class. We have a set programme and we plan to finish the programme. Lectures will start punctually.

A lecturer is under no obligation to supply information or repeat course content for the benefit of absentees or latecomers. (No lecture notes will be provided to those who do not have a valid excuse for absence from a lecture)

3. Calculators

You are not permitted to use a calculator for your class work or homework in first year to help develop your mental mathematics skills.

4. Homework

Students do not make progress unless they do tasks set for homework, regularly. We expect each student to spend at least 1 hour per week on homework. It is important that students are well prepared when they come to class. You will receive a mark for completed work, which contributes to your year mark.

LEARNER MATERIALS

No textbook is required. Material will be made available in the form of summarized notes and transparencies. You will be required to make your own notes in class.

You must obtain a file for use in this subject only. Please insert this subject guide and all class notes into the file. All personal notes taken from the board as well as examples, should also be placed in the file. Homework, spot tests, modular tests and other class tasks should also be placed in the file.

STUDENT SUPPORT

1. Tutor program

The university provides a peer tutor system to support mathematics students, free of charge.

If you should require extra help in mathematics, contact the tutor co-ordinator, telephone numbers available on the mathematics notice-board outside lecture room 1.16.

2. Computer Package

The complete Master Maths programme is installed on the faculty computer network and can be accessed from the students computer workroom. The Master Maths program offers a complete tuition program of the school mathematics curriculum Grade 1-12 and is based on the current school curricula. To access the program, you first need to register with the technical assistant in the computer room.

3. Library Resources

There is a file of past exam papers available in the library for students to copy as well as numerous maths textbooks which should be consulted if a student experiences any problems.

APPENDIX F: SUBJECT GUIDE – INTRODUCTION TO MATHEMATICS

TIME ALLOCATION

The course runs for the whole year, i.e. 24 weeks. Two periods per week are allocated for mathematics content and didactics.

SUBJECT GUIDE 2007

Specific Subject Didactics: Learning Area 1 - Mathematics.

Faculty: Education, Mowbray campus

Department: General Education & Training (GET)

Course: BEd GET: Foundation Phase; Intermediate and Senior Phases

PURPOSE OF COURSE

To introduce the student to key aspects of Mathematics teaching in Outcomes Based Education.

SUBJECT COURSE OUTCOMES

The student should be able to:

- Identify the underlying principals of Outcomes Based Education and the Revised National Curriculum Statements.
- Demonstrate a pedagogical understanding of the different mathematical topics as set out in the curriculum.
- Participate in activity based learning and open-ended investigations.
- Experience and manage co-operative learning in the classroom, making use of different ways of grouping to manage the mathematics classroom.
- To develop, through practical experience, knowledge of various strategies for teaching mathematics.
- Develop an understanding of Mathematics anxiety and the impact thereof on Mathematics learning
- Demonstrate skill in writing lesson plans for teaching mathematics concepts.

ASSESSMENT

The pass requirements for the course are: The final mark must be at least 50% in order to pass. This final mark is calculated using the results from the tests, assignments and projects carried out during the academic year.

To give students a fair opportunity to demonstrate their knowledge, understanding, skills and attitudes; a balanced variety of assessment techniques will be utilized and a number of assessment opportunities be provided during the academic year.

The assessment tasks for the year is briefly explained below:

Assessment activity	Weighting
Maths anxiety essay	**25%**
Maths anxiety interview	**25%**
Lesson plans	**25%**
Test	**25%**

SUBJECT CONTENT

1. The culture of the Mathematics classroom

The student should be able to:

- Examine and discuss their own Mathematicss anxiety and represent the extend of this anxiety in a visual way
- Interview and observe learners in the classroom with Mathematics anxiety
- Discuss the causes and effects of Mathematics anxiety and teaching strategies to cope with this.

2. Number

The student should be able to:

- Examine, evaluate and discuss various strategies that children use to operate with numbers
- Use non-standard methods (children's strategies) to operate on numbers
- Distinguish between teaching number for conceptual understanding and the use of algorithms in the classroom
- Experience and examine the use of a 120 chart, flard cards and other manipulatives in the classroom

3. Mathematics and the RNCS

The student should be able to:

- Understand the critical outcomes for Mathematics Education
- Explain the kind of teacher and learner envisaged by the RNCS
- Define mathematics
- Differentiate between knowledge and skills of Mathematics Education
- State the purpose of Mathematics Education
- Explain the five Learning Outcomes in Mathematics Education and the focus of each Outcome in the Intermediate phase

4. Lesson planning

The student should be able to:

- Observe a classroom lesson and write up a corresponding lesson plan
- Understand the underlying principles of lesson planning

5. Measurement

The student should be able to:

- Discuss an instructional sequence for teaching elementary Measurement
- Identify the skills and knowledge for teaching Measurement

METHODOLOGY AND TIME MANAGEMENT

1. Teaching method

Instruction will include a combination of lectures, practicals, individual and group work, with ample opportunity for self-activity and discussion.

2. Attendance and Punctuality

One hundred percent attendance is required from you. The nature of the subject, and the way in which we present it, is such that attendance of ALL students is required. In case of illness or any valid reason, absence MUST be explained to the lecturer as soon as you are back in class. We have a set programme and we plan to finish the programme. Lectures will start punctually.
A lecturer is under no obligation to supply information or repeat course content for the benefit of absentees or latecomers. (No lecture notes will be provided to those who do not have a valid excuse for absence from a lecture)

LEARNER MATERIALS

No textbook is required. Material will be made available in the form of summarized notes and transparencies. You will be required to make your own notes in class.

TIME ALLOCATION

The course runs in conjunction with the course for Introduction to Mathematics. Mathematical content (Introduction to Maths) and didactics (the course described above) have been merged to give students a holistic picture of Mathematics teaching. It will be made clear during the teaching of Introduction of Mathematics when the content is related to **Specific Subject Didactics: Learning Area 1 - Mathematics**.

APPENDIX G: DATES OF INTERVIEWS WITH RESPONDENTS

Interviews with respondents

No	Name	Date
1	Fran	15 May 2007
2	Jane	22 May 2007
3	Mandy	22 March 2007
4	Mira	29 May 2007
5	Morgan	16 March 2007
6	Nora	18 March 2007
7	Ntobi	6 March 2007
8	Olive	14 March 2007
9	Sandy	22 March 2007
10	Thabi	9 March 2007
11	Vosi	4 April 2007
12	Xhosi	25 May 2007