# A values-based approach to promoting excellence in mathematics education

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**TITLE OF PROJECT:** A values-based approach to promoting excellence in mathematics education

**DECLARATION**:

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

**SIGNATURE:** _____

**DATE:** 19 July 2010

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# ABSTRACT

This research study has emerged as a result of my concern regarding the apparent low self-efficacy amongst initial teacher education students in my mathematics education classes. It also reflects a reported renewed interest in values, and the promotion of excellence in education. The effects of a values-based approach to mathematics education towards improving students' self-efficacy and promoting excellence have been investigated, grounded within my ontology of excellence in mathematics education, which incorporates the values of respect, fairness, accountability, honesty and compassion. An inquiry-based teaching and learning approach formed the framework within which the study took place. Notions of 'new scholarship', premised on the view that teaching is about engagement in participatory learning, and the development of communities of creative students, provided the theoretical framework. Both quantitative and qualitative data gathering methods were used. Data-collection tools included affective-disposition statements, interviews, journal entries, as well as a video recording of a mathematics education lesson. The quantitative and qualitative data generated suggest improved levels of self-efficacy amongst the students who participated in the study. The data also suggest that a values-based approach to teaching can be used as an effective approach by mathematics teachers – and mathematics teacher educators – for the purpose of promoting the pursuit of excellence. As teacher education worldwide is currently characterised by a lack of vitality in teacher preparation (Grossman, 2008), the findings of this study should provide insights for teacher educators, teachers and policy makers who wish to promote mathematics self-efficacy, excellence and facilitate enhanced vitality within the teaching profession.

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# INTRODUCTION AND OVERVIEW

## 1. INTRODUCTION

Boyer (1990) speaks of the need to develop a new scholarship of teaching, viz. a form of scholarship that focuses on teaching itself as the focus of inquiry, and which aims at creative engagement with the subject matter. Schön (1995, p. 27) believes that this type of approach necessarily involves using a form of action research "with norms of its own", and which holds promise for the development of new forms of networking in the spirit of communicative action (Habermas, 1987). McNiff and Whitehead (2002) propose that action research of this type is one way of addressing calls by Snow (2001) and Hiebert, Gallimore and Stigler (2002) for the development of a knowledge base that provides ways of systematically recording the 'rich resource' of practical knowledge that teachers generate from studying their practice.

This study was informed by notions of 'new scholarship', and was premised on the view that teaching is about engagement in participatory learning and the development of communities of creative scholars by means of a curriculum that takes the form of constantly emergent thoughtful conversations (McNiff & Whitehead, 2002). My concern in this instance, was firstly, the low self-efficacy in terms of mathematics and mathematics teaching that I have perceived amongst many of the initial teacher education students whom I teach, and secondly, about issues of values (or the apparent lack thereof) in contemporary society (Kidder, 2005).

In an attempt to generate thoughtful conversations around these two issues in the context of my teaching, I investigated whether it is possible to influence my mathematics education students' self-efficacy through a shared understanding and vision of values which pertain to, amongst others, issues of excellence. In doing so, I focused on my own value system and those espoused by the Faculty of Education at the Nelson Mandela Metropolitan University (NMMU) – in order to reflect on and improve my teaching strategies.

I attempted to develop and live out my own 'living theory', in order to generate an acceptable claim to new knowledge, by networking with my students in the spirit of communicative action (Habermas, 1987).

## 2. MY CONCERN

I have been a lecturer at the Nelson Mandela Metropolitan University since 1993, and have been involved with teaching both in-service mathematics teachers, who have been upgrading their qualifications, as well as teaching mathematics education to initial teacher education students. As I reflect on my early years at the university, I realise how teacher-centered my own outlook on education was. My lecturing style was very traditional, and I was comfortable disseminating knowledge without allowing students to become fully engaged in the learning process.

My own studies in teacher training took place at a time when expository teaching and learning strategies were being promoted. My own schooling was characterised by traditional chalk-and-talk lessons, teacher-centered activities, and learners who were predominantly passive recipients of knowledge. Similarly, my schooling was characterised by an implicit (and explicit) teaching of moral values, as was my family life. However, since the 1990s there has been a great deal of political

and social change in South Africa and the world. Education has moved towards more constructivist and inquiry-based teaching and learning strategies, and in the 1990s I gradually came to realise that different approaches were needed to motivate the very diverse population of students in my classes.

Over the years I have endeavoured to make gradual shifts away from my comfortable traditional base to more innovative teaching and learning strategies, so as to encourage students' enjoyment of mathematics education classes and to encourage the development of positive attitudes towards mathematics. More specifically, I am very concerned about the high levels of negativity many initial teacher education students and teachers display towards mathematics and mathematics teaching, as I believe that all initial teacher education students can enjoy and do mathematics, given a classroom climate which fosters optimal learning.

The possible influence that my understandings of morality, and the actions I take based on these (often fuzzy and implicit) beliefs, have had on my students' ability to take a life-affirming view of themselves as competent and valuable individuals, is of great importance to me. As such, this study was grounded in my ontology of excellence, which I believe is a notion grounded within the values of respect, fairness, accountability, honesty, and compassion. These, in turn, include the notion of trust. My awareness and more-focused understandings of moral grounding, and the worldwide movement towards more constructivist and inquiry-based teaching and learning strategies, have underpinned this research study. This, I believe, has enabled me to make a claim to new knowledge about enabling student teachers to develop a more life-affirming view of themselves and a belief in their own ability to do and teach mathematics. As our attitude is an indicator of how we see life, I have, subsequently, endeavoured to influence students' self-efficacy, by encouraging them to adopt an

affirming attitude which sees the good in life, and therefore, draws the good from life experiences. As such, I have endeavoured to encapsulate my educational concern as a mathematics education lecturer to initial teacher education students in the following research question:

> *Can I influence my students' mathematics self-efficacy by using a values-based approach to teaching and learning which aims at promoting excellence?*

## 3. THEORETICAL FRAMEWORK

This study is grounded in literature of self-efficacy, excellence, moral values, inquiry and constructivist theories of teaching and learning, the expected outcomes and assessment standards of the South African National Curriculum Statement and the perceived strengths of action research and the 'new scholarship' approach.

### 3.1 Self-efficacy

Nicolaidou and Phillippou (2003, p. 1) claim that "a person's behaviour and choices, when confronted by a task, are determined more by beliefs and personal theories than by knowledge of the specifics of the task". A great deal of current literature describes poor self-efficacy in terms of students doing mathematics.

Pastoll (2002, p. 19) asks: "How much damage has been done in the name of 'education' as a result of this phenomenon of failure? And how much more damage are we going to allow to happen while we evade our responsibility as educators?" He asserts that failure is not the alternative to success; and he believes that failure is a completely separate, unnecessary and confidence-destroying invention, artificially created by schools and educational authorities. Pastoll further explains that all through life we are susceptible to not quite succeeding at some of the tasks and goals we set ourselves. We

need to embrace the notion that it is natural to make mistakes, and that someone who has learnt a lot through experience is called wise, not a failure. Pastoll believes that a student, who does not measure up to a standard, and is labelled for it, bears that stigma - not just for the rest of the course - but for the rest of his life.

According to Pajares (2002), students who perform well in mathematics are likely to develop a strong sense of confidence in their mathematical capabilities, whereas poor performance generally weakens students' confidence in their capabilities. Bandura (1994) reaffirms the belief that a strong sense of efficacy enhances human accomplishment, while people with low levels of efficacy are prone to doubt their capabilities and to find difficult tasks threatening. Pajares (2002) further advocates that highly regarded teachers – who model excellence in their teaching – can use their educational influence to encourage self-belief in students.

As many students in my mathematics classes appear to have poor self-belief in their own ability to do mathematics, I was committed to investigate how best I could encourage students to fulfil their potentials, both personally and academically. I interrogated my own practice via data generated within action-research cycles, in order to increase my educational influence to enable my students to develop greater self-efficacy in this subject.

### 3.2 Notions of excellence

The Collins English dictionary defines excellence as, '*the state or quality of excelling.*' Landmark Education uses the following explanation:

> *Excellence is not a matter of ability, knowledge or practice. It cannot be taught, imposed, or wished into existence. Excellence is a matter of the stand we are and the stand we take – a stand that allows for performance*

*that surpasses what was previously possible, performance that defies old limits and maps new territory.*

I believe that it is this quest for excellence that fuels our fire, and keeps us from mere complacency in life.

In this study I have pursued personal excellence with the expectation of achieving the goal of improving my own practice and exercising my educational influence in improving the mathematics self-efficacy of the students in my classes. I intentionally lived out my own understanding of excellence, which incorporates my values of respect, fairness, accountability, honesty, and compassion, together with the belief that my students have the ability to develop a life-affirming view of themselves as competent and valuable individuals. In this way, I believe that I have influenced my students' growth towards greater self-efficacy within a climate of trust and integrity.

### 3.3 Moral Values and Self-efficacy

Woolfolk (2004) strongly believes that the importance of appreciating students' understanding, enabling them to feel valued and respected, and nurturing their sense of self-efficacy are all key elements of effective teaching. She further emphasises the need for respect and trust in classroom relationships, and points out that when students see teachers as caring and capable, they are much more likely to co-operate in classroom activities. Her experience has shown her that without students' trust, respect and co-operation, even the best teaching materials and methods can fail. She explains achievement in terms of ability, self-efficacy and opportunity. My challenge in the classroom situation was, therefore, to familiarise myself with students' understandings, provide opportunities for students to experience success and wellbeing, and create learning environments that foster positive self-efficacy amongst students.

The ontological values described earlier inspired my reasons and purposes for this research study, and my intention was to critically reflect on and improve my values-based teaching and learning strategies, so as to influence my students' motivation to move away from their present, generally poor self-belief in their own ability to do mathematics, to my ideal picture of students with a life-affirming view of themselves as competent and worthwhile people, with high levels of self-efficacy.

My research study was therefore underpinned by the type of question asked by Whitehead (1989), viz. 'How can I improve what I do and develop a living theory of my practice?'

### 3.4 Inquiry and constructivist theories of teaching and learning

Inquiry-based learning is supported by constructivist principles and the findings of Piaget and Vygotsky (Engel, 1996). Piaget viewed learning as an internally driven process, an individual construction, which results from learners engaging with their world, whereas Vygotsky argued that learners acquire knowledge in the course of social relationships. The learner does not construct his/her own knowledge independently, but finds that learning occurs on a social level, within a particular cultural context (Western Cape Department of Education, 2000; Moll, 2002).

Llewellyn (2005, p. 27) highlights the fact that constructivist learning strategies are compatible with inquiry and learner-centered classrooms. He holds that "a prerequisite for becoming an inquiry-based teacher is embracing a philosophical mind-set founded on the ideals and principles of constructivism". Layman (1996) describes inquiry-based learning as continually encouraging students to translate new experiences and concepts into workable solutions through experimentation. Through leaps of

insight, trial and error, argumentation, and frustration, students apply the concepts of mathematics (or any other discipline) to expand what they know and are able to do.

According to Treagust et al. (1996) constructivism focuses on the way in which learners construct viable and useful knowledge. Smerdon et al. (1999) describe constructivism as being based on the premise that learners actively construct knowledge and reconcile new information.

In my experience, mathematics teaching traditionally tends to follow a task-orientated approach. This is confirmed by Maree and Fraser (2004, p. 6) who state that "teaching and learning were, and still are, very much content-based in a significant number of schools in South Africa. The focus of content-based learning is on prescribed syllabi which learners must master".

In my teaching I have intentionally encouraged a shift away from this focus to a more relational orientation and practice. Where relevant and meaningful, I have endeavoured to use inquiry and constructivist approaches to teaching and learning within an atmosphere of respect and trust, the type of classroom climate which research suggests, and I believe, promotes students' self-efficacy towards mathematics education.

### 3.5 Complex learning communities

Within a complex learning community in the mathematics classroom, many events and systems emerge through the interactions of students who are themselves dynamic, adaptive and capable of responding in different ways to similar influences, and who can learn new responses (Weaver, 1948). There are several necessary, but not sufficient conditions that need to be met for a complex learning community to arise and maintain itself (Davis and Simmt, 2003). These conditions, which have been adapted from Bloom (2000), Casti (1994), Kelly (1995), and Lewin and Regine (2000), are

internal diversity, redundancy, decentralised control, organised randomness and neighbour interactions.

Internal diversity reflects the different way in which members of a community can respond and interact. Redundancy is the 'sameness' of the individuals within the learning community. This could include knowledge, purpose, background etc. According to Davis and Simmt (2003), redundancy is essential for triggering a transition of *me's* to a collection of *us*. Decentralised control is a situation where power and authority are distributable, the locus of learning is the individual, the system itself 'decides' what is and what is not acceptable, and the understandings and insights are co-specified and shared.

The condition of organised randomness is the delicate balance between enough organisational control to direct activities, and enough randomness to allow flexible and varied responses. Within the notion of organised randomness, Davis, Sumara and Luce-Kapler (2000) coined the term 'liberating constraints', i.e. those that are not too prescriptive or too open-ended, but something a little more enabling, such as, 'tell me what you consider to be the five most important things about geometry'.

Finally, there are agents within a complex system that affect ideas and activities. These agents are termed neighbour interactions. In the sense of complexity theory and learning communities, as promoted by Davis and Simmt (2003), these 'neighbours' are not 'physical bodies or social groupings', but 'ideas, hunches, queries and other manners of representation' which must 'bump' against one another. It is the interaction of concepts and understandings that fosters a complex learning community.

## 3.6 South African National Curriculum Statement

The South African Department of Education Strategic Plan (for 2008-2012) clearly states the vision. This is to impact more urgently and directly on poverty, unemployment and social cohesion, by providing quality education for all. This strategic plan further acknowledges the following implementation plans:

- Ensuring the effective implementation of the curriculum for improved learning;
- Attracting and retaining appropriately qualified and competent teachers, with the emphasis on scarce skills;
- Increasing the participation and success rates of girl learners in gateway subjects.

The above implementation plans suggest the promotion of quality education amongst communities of learners, particularly in scarce skills, which would include mathematics education. The purpose of this research study has, therefore, aligned itself with the vision of the South African National Curriculum Statement.

## 3.7 The 'new scholarship' approach

I drew on the work of key authors to guide my study and to act as my conceptual framework in terms of 'new scholarship'. The work of Whitehead (1989) and Whitehead and McNiff (2006) on the living nature of educational inquiry; the work of McNiff (2007) on the generative transformational nature of educational relationships; and the work of Biesta (2006) on educational responsibility, infused the study.

These broad frameworks embed secondary frameworks, which are themselves in a dynamic transformational relationship in the generation of living educational theories. These contain ideas taken directly from McNiff (2007) about the following:

- The immanent and genetically endowed capacity for human growth, drawing on the generative transformational work of Chomsky;
- The interrelationship of all things, drawing on the transformational evolutionary work of Bateson, and the ideas of Buber, Fromm and Tillich, as well as on the environmental philosophy of Zimmerman *et al;*
- The inevitable capacity for human influence, drawing on the ideas of Foucalut and Said;
- The capacity of humans for making choices on the exercise of their influence, drawing on the work of Berlin;
- How the production of living educational theories can influence the education of social formations (Whitehead, 2004) for sustainable global wellbeing;
- The transformation of communities of practice into communities of educational inquiry through dialogical interaction.

(McNiff 2007)

The literature referred to in this chapter draws attention to the theory and ontological values on which this study is grounded. After extensive engagement with the research of others, I was better positioned to interrogate my practice of teaching mathematics education to initial teacher education students, as I used a values-based teaching approach to influence students' self-efficacy and contribute to the pursuit of excellence.

## 4. RESEARCH DESIGN

The nature of this 'new scholarship' research study justified the use of both quantitative and qualitative methodologies – in order to ensure relevant, appropriate and

adequate data collection. According to Johnson and Christensen (2004), and Cresswell (2005), the use of multiple perspectives, theories and research methods may be viewed as strengths in educational research. Johnson and Turner (2003) advocate the collection of multiple data, by using different strategies, approaches and methods, in such a way that the resulting mixture or combination is likely to result in complementary strengths and non-overlapping weaknesses. As such, I used a mixed-methods approach and included multiple perspectives on the notion of values, self-efficacy, excellence and complex learning communities. This approach, I believe, helped to improve the quality of my research, because the different research methods had different strengths and weaknesses, while multiple perspectives assisted in understanding the complex conditions which influenced the study.

In the case of this educational research study, in which I have attempted to improve my educational judgements and decisions, the quantitative and qualitative research methods were viewed as being complementary.

## 4.1 Problem Statement

The reason for this study is my concern that many students in my mathematics classes display low levels of mathematics self-efficacy, and seldom express life-affirming views of themselves as competent and valuable individuals. Despite the fact that inquiry-based learning is a core methodology required by the National Curriculum Statement (Department of Education, 2002; 2007), the majority of students at school level learnt mathematics by memorisation and rote learning. This has not proven conducive to the promotion of mathematics self-efficacy (Woolfolk, 2004). Inquiry-based learning recognises and responds to student diversity and encourages all students to participate fully in the learning process (NSES, 1996).

Against a backdrop of national concern about the negativity towards mathematics (Asmal, 2000), I used a values-based teaching approach to influence my students' mathematics self-efficacy. This aimed at promoting an environment of trust and the pursuit of excellence.

My goal for this research study was to improve my own practice, and in so doing to fulfil my potential as a teacher educator in mathematics education with initial teacher education students.

The population of student participants consisted of 79 first-year students and 51 second-year students. My intention was to be an influential role model for aspirant mathematics teachers, and to use my educational influence to encourage students to assess their own self-beliefs and develop a life-affirming view of themselves as competent and valuable people.

## 4.2 Research Question

This study has interrogated my own teaching practice with initial teacher education students; and it has examined the extent to which I am able to use my educational influence in promoting students' self-efficacy and contribute towards the development of a complex learning community of students. The primary research question for this study was, therefore:

> *Can I influence my students' mathematics self-efficacy by using a values-based approach to teaching and learning, which aims at promoting excellence?*

As I continually interrogated my own practice of teaching mathematics education to initial teacher education students, I have also critically evaluated the

findings of this research study in the light of the following subsidiary questions which underpin the primary question:

- Did I manage to live my values in my mathematics classes?
- Did my behaviour contribute to a sense of trust in my students and a shared belief in my notion of excellence?
- How did my approach contribute to achieving the conditions required for a complex learning community of students?
- Did my approach influence my students' sense of self-efficacy?

My intention was to reflect on and refine my strategies – in order to improve my values-based practice that I used with students who were registered for the intermediate phase initial teacher education B Ed degree. The ultimate aim was to influence their self-efficacy and assist them in adopting a life-affirming view of themselves as individuals and as mathematics teachers.

## 4.3 Method

As noted earlier, my aim was to contribute to a 'new scholarship' of educational knowledge (Whitehead, 1989). This I planned to do by studying my own educational practices, as I attempted to provide quality educational experiences for the students in my mathematics classes. I have observed the principles of methodological rigour of action research (Winter, 1989), as I have described my data-gathering processes. I generated evidence to test my claims that I encouraged students to develop a life-affirming view of themselves – and develop a belief in their ability to do mathematics with enjoyment and confidence.

I adopted a self-study participatory action-research approach, which drew on the work of key authors, such as Whitehead (1989), and McNiff and Whitehead (2006)

about the living nature of educational enquiry. The work of McNiff (2007) describes the generative transformational nature of educational relationships, while that of Biesta (2006) focuses on educational responsibility. In doing this, I pursued a systematic enquiry of self-study of my professional practices as a university lecturer–researcher, thereby improving my practice. These findings can now be made public.

I actively interrogated, reflected on and analysed the evidence I collected to reach an understanding of some of the reasons which underpin students' low self-efficacy towards mathematics. I continually modified my ideas and practices as a cyclical process in the light of new evidence. The cyclical process consisted of implementing teaching and learning strategies, realising the outcomes of implementation, modifying existing strategies, evaluating modified action – and then beginning a new cycle using the same steps. In this way a cycle of change and enquiry evolved.

### 4.4 Research participants (sample)

Initial teacher education students in my mathematics education classes (n=130) constituted the body of the research participants. The research participants consisted of first-year students (n=79) who had selected the mathematics and science major option for their degree course, and second-year students (n=51) who had selected the language major option. Both groups of students, who were between the ages of 18 and 25 years, were registered for their first mathematics education course in their pre-service teaching studies at the Nelson Mandela Metropolitan University in the Eastern Cape province of South Africa. I required that participating students in this research study should keep a scaffolded reflective journal throughout the semester of mathematics education classes. I solicited their consent to read and respond to their journal entries for the purposes of meaningful communication with them, and also for gathering data.

## 4.5 Data collection and data-collection instruments

The data generated included student responses to affective-disposition statements, journal prompts, focus-group interviews, the analysis of a video representation of a mathematics education lesson which I had taught, as well as discussions and feedback received from students. The analysed data informed me on how I was influencing the students' personal self-perceptions and their perceptions regarding their mathematical abilities.

Prior to the students engaging in the mathematics education module, they were requested to respond to an affective-disposition statement, in order to establish their motivational levels and their belief in their own abilities to do mathematics. These findings enabled me to reflect on my teaching strategies and purposefully implement interesting, relevant and active teaching-and-learning activities during mathematics education classes. It was envisaged that these activities might influence my students' learning and attitudes in mathematics education.

The findings of the post-intervention affective-disposition statement indicated the degree to which students had enjoyed participating in the mathematics education course, and whether their engagement in the mathematics education classes had influenced their levels of mathematics self-efficacy.

The data generated via regular interviews with focus groups of students were used to continually monitor, assess and adapt my teaching strategies – to encourage the development of students' self-efficacy with regard to mathematics concept development and teaching. Interviews with students took the form of pre-, mid- and post-intervention interviews, while students were engaged with the mathematics education module, PICM 201.

The value of using interviews to collect data for this research study is expressed in the following extract from Evans, which is cited in Volbrecht et al. (2005, p. 19):

> *In every country, experience shows that some people find personally transforming the experience of trying to articulate for themselves what they have actually learned, although they did not know they had learned it. Confidence can be boosted. Aspirations can expand. Motivation for learning is often strengthened. And as the sense of self is strengthened, so the world can become a better place. Often this is referred to as the empowerment of the people.*

Students were encouraged to make regular entries in their reflective journals for the purpose of recording their perceptions, challenges and experiences of their own transforming self-beliefs and ability to do mathematics. The use of self-reflection is strongly supported by Bandura (1997), who considered self-reflection the most uniquely human capability. He believed that through this form of self-referent thought, people can evaluate and alter their own thinking and behaviour.

He asserted that how humans think and make decisions is an important factor in understanding their behaviour. The personality theory, Cognitive Experiential Self-Theory (CEST), as described by von Winterfeldt, et al. (1986), proposes a relationship between different ways of thinking and behavioural change.

According to Whitehead (2004), multimedia representations offer validity for the methodologies implemented in the classroom situation; and they show the lived reality of lives in action. I, therefore, felt that it was important to make a video representation of one of my mathematics education lessons with my students. This enabled me to reflect on my practice, discuss the effects of teaching strategies implemented with

students, and investigate the educational influence my teaching had with regard to students' self-efficacy and belief in their own ability to do and teach mathematics. In examining my own teaching practice, I considered alternative and additional strategies that I used to improve my practice.

I used literature findings, student journal entries, responses to affective-disposition statements, interviews, a video representation of a lesson, discussions and feedback to develop meaningful teaching strategies for encouraging students to fulfil their potential – both personally and as mathematics students. The interrogation of my practice, in an attempt promote my students' self-efficacy with regard to mathematics, was the focal area of my research study.

### 4.6 Data analysis

The data generated by student achievement and verbal and written responses to these strategies were then analysed – in order to inform my practice, as I taught. I used my values, as described in this study, as living standards of judgement, applying both personal and social validation measures. In order to do this, I drew on Habermas' (1976) criteria of social validity to explain what it means to engage in the critical processes of reflexive and dialectical critique. In this way, the participants and I critically engaged with one another's learning.

We had collaborative discussions on how my teaching and learning strategies could contribute to sustainable social orders, and how best the validity of knowledge claims could be assessed through processes of democratic evaluation.

I adapted my practice accordingly, as I taught, recorded my findings and the changes I made – in order to improve and change the implementation strategies to further promote self-efficacy in mathematics. I implemented the findings of this

research as a cyclic implementation plan, which alternated between action and critical reflection. The findings of one cycle became the beginning of a consecutive cycle of reflection and investigation into my own practice of encouraging students to embrace a life-affirming attitude and promote their self-efficacy.

As mentioned earlier, an affirming attitude sees the good in life, and therefore, draws the good from life experiences. Self-study action research is thus an emergent process, which took place as understanding increased and contributed to my transformation and growth. This, I believe, was reflected in my practice.

A significant feature of this research study was how I tested the validity of my claims to have influenced my pre-service students' levels of self-efficacy. I tested the validity of my emergent knowledge claims, as they became apparent, through the affective-disposition statements, student-reflective journal data, interviews, and a video representation of a lesson.

I explained the processes involved in my epistemological, social and cultural transformation. I invited the student participants in my classes to offer critical comments on the validity of my claims of contributing to knowledge and processes of knowledge creation. In so doing, readers were assured that no claims had been based on personal opinions.

The intention of this action research study was that it would generate my living theory, as I investigated and improved my own practice and exercised my educational influence in my pre-service teachers' self-efficacy in terms of mathematics education. As noted earlier, this study took the form of cyclical findings, where the culmination of one action research cycle became the beginning of a new one – each cycle informing teaching and learning strategies for the next cycle.

I discussed these findings with participants and critical friends, so that I was able to clarify my own interpretations of the findings, what I had learnt through the research findings – and how this learning informed new learning. When I recognised teaching, learning and research strategies which were not successful in improving the levels of self-efficacy and achievement of students, I engaged with the problematics of the disconfirming data, reflected on these, and then shared my thoughts with the relevant participants of this research study.

After collaborative discussion, I planned to do things differently, where appropriate, with the intention of achieving more positive outcomes.

## 5. ETHICAL ISSUES

I submitted my proposal to the university ethics committee and secured their permission before proceeding with my doctoral studies. The nature of this research study was explained to all the students, and they were assured that their integrity would be protected throughout the study. Students were told that their participation in the study would directly benefit mathematics education teaching and learning for the B Ed (IP) pre-service teachers' studies. Students voluntarily gave their informed consent to participate, and were made aware that they could disengage from the research at any time, without any negative consequences to them personally or academically.

Hedges (2001) asserts that any participation in research should be voluntary; and, consequently, it is essential that the student teachers should feel free to withdraw from participation at any stage.

## 6. OUTLINE OF STUDY

Chapter One provides a general introduction and overview of this self-study participatory action-research; and it explains how I used a values-based teaching approach to influence students mathematics self-efficacy. I explain inquiry and constructivist theories of teaching and learning, and how this study aligns itself with the vision of the South African National Curriculum Statement. The theoretical framework describes how this research study is underpinned by the relevant literature, grounded in ontological values, and implemented within a complex learning community in the mathematics classroom environment.

I describe the appropriate mixed-method approach I used for data collection, the instruments used, and how I tested the validity of my claims to new knowledge against the confirming evidence produced by data analysis. The adherence to ethical conduct is described throughout.

Chapter Two provides a more comprehensive literature review of theoretical frameworks of efficacy; inquiry-based teaching and learning, underpinned by constructivism; conditions required for the development of a complex mathematics learning community; new scholarship as a research approach; my ontology of values, together with the values of the Education Faculty of the Nelson Mandela Metropolitan University, and then relates these to notions of excellence, which inform my mathematics teaching and learning practices.

Chapter Three provides an outline of the research design and includes the reason for the particular research approaches and for the methods used. The types of data required and the techniques and tools used for gathering data, including the use of affective-disposition statements, interviews, student-reflective journals and a video

representation, are all discussed. A description of the methods used to analyse the data obtained is also included.

Chapter Four examines the results of the data analysis and the findings of the research study. The quantitative and qualitative data obtained from the affective-disposition statements, interviews, a multimedia representation, observations and student-reflective journals were statistically and descriptively analysed and triangulated. In this way, I generated evidence to test my claims that I used my educational influence to encourage students to develop a life-affirming view of themselves, and to develop a belief in their ability to do mathematics with enjoyment and self-confidence.

Chapter Five is a discussion and interpretation of the results reported in Chapter Four. The findings pertaining to each subsidiary question are addressed and the analysis of the qualitative and quantitative data are related to the theoretical underpinnings, noted in previous chapters, and their relevance to the research question is described. The implications of the findings for new teaching and learning practices for mathematics education are discussed and the conclusions drawn.

Chapter Six discusses the implications of the findings described in Chapter Five for mathematics education teaching and learning.

# CHAPTER TWO

# THE LITERATURE REVIEW

## 1. INTRODUCTION

In this chapter I describe the historical and political context of education in South Africa as it applies to teaching practices. An outline will be given of the broad concept of constructivism and inquiry-based teaching and learning, as well as the various definitions of these concepts. I briefly examine how a traditional education system discourages the natural process of inquiry, and furthermore, I highlight the importance and implications of inquiry for both teachers and learners.

Current thinking on inquiry learning and constructivism will be reviewed, and a correlation drawn between the two approaches to teaching and learning. I also give a brief outline of the notion of self-efficacy, and how students' self-efficacy affects their belief in their ability to achieve in mathematics education.

The current debate on values and moral education for teacher-education programmes, and the importance of integrating core values and vitality into teacher education programmes, will be considered. The importance of creating opportunities which foster excellence, and in which students are able to experience success is discussed. Conditions required for the development of complex mathematics learning communities will be described in detail, as well as the conditions necessary for influencing levels of engagement, enjoyment and confidence within these complex mathematics-learning communities.

Notions of 'new scholarship' premised on the view that teaching is about engagement in participatory learning, and which uses action-research practices wherein teachers and teacher educators generate data as they study their own practice, will also be elucidated.

The issues discussed above provide the theoretical framework and rationale for the research question of this study: *Can I influence my students' mathematics self-efficacy by using a values-based approach to teaching and learning which aims at promoting excellence?*

## 2. BACKGROUND

Over the past three decades, since the release of the de Lange Report in 1981, it has become apparent that the problems surrounding science and mathematics education have contributed significantly to the current South African national crisis in education. Little has changed to date; learner achievement is still very poor in general, and there is a large number of under-qualified primary and secondary school teachers who do not have the knowledge and skills to teach these subjects competently (Taylor & Vinjevold, 1999; Asmal, 2000; Fleisch, 2007).

The above factors are exacerbated by the fact that teaching and learning usually take place in a second language, and in under-resourced classrooms (Taylor & Vinjevold, 1999).

The Human Science Research Council (HSRC) of South Africa published a number of reports on the teaching of physical science and mathematics in 'white' education in South Africa in the late 1970s and early 1980s; and as early as 1981, the de Lange commission highlighted the crisis in 'black' education in South Africa with

extremely poor teaching and the dysfunctional learning of science and mathematics. However, according to Howie (2001), it was the results of the Trends in International Mathematics and Science Study (TIMSS) in 1999 that finally shocked the nation, revealing that South Africa had been outperformed by all the other thirty-seven participating countries in both mathematics and science.

The results of the 2003 TIMS study, in which fifty countries participated revealed that South Africa had again been placed last. A report in the Financial Mail (December 2004) noted that there had been no significant difference in South African learner performance between 1999 and 2003. South Africa chose not to participate in the 2007 TIMS study; and there is currently no indication whether the TIMSS of 2011 will attract further participation from South Africa.

South Africa's positioning in international studies on the teaching and learning of science and mathematics, and the failure of the educational system to deliver appropriately equipped mathematics and science school leavers, amounts to a national crisis in mathematics teaching and learning. Currently, the South African government is under tremendous pressure to meet international standards, particularly with regard to science and mathematics teaching and learning (Christie et al., 2007).

Research has shown that South African teachers appear to be unable to communicate attitudes of curiosity, respect for evidence, and critical reflection – necessary for the development of higher-order cognitive skills (Enslin, 1990). Grossman (2008) asserts that teacher education, as a field worldwide, has been proclaimed to be in crisis, a crisis epitomized by the lack of vitality in teacher preparation. She describes how university-based teacher education is being questioned in terms of its relevance, and doubted as to its contributions to student learning.

Grossman (2008) believes that this crisis should be used as an opportunity for teacher-educators to strengthen their commitment to rigorous research and to work to improve teacher education based on the evidence of its outcomes.

Gatlin (2009) asserts that responding to the crisis in teacher education requires innovative thinking, and a concerted effort to construct a new paradigm that encourages, rather than stifles, vitality. Fraser (2007) asserts that the state of teaching and teacher education is the result of more than a century of compromises and the adjustments demanded by the exigencies of another era. Although Fraser was referring to the education system of the USA, this comment is just as appropriate to the current education crisis being experienced in South Africa.

According to Hess (2005), revitalising teacher education is best tackled as part of the effort to re-imagine and reshape teaching for the realities of 21st century education. The Revised National Curriculum Statement was introduced in an attempt to bring about fundamental changes to the mathematics curriculum: how it is taught and how the learners learn (Department of Education, 2002).

## 3. THE NATIONAL CURRICULUM STATEMENT

As noted above, since the new political dispensation in South Africa in 1994, a new national curriculum has been developed which was legislated in 1995. The new government, largely represented by the formerly oppressed constituency, opted for a liberal, progressive model of education. The new South African curriculum had a clear political agenda aimed at transcending the curriculum of the past, which perpetuated race, class, gender and ethnic divisions and emphasized separateness, rather than common citizenship and nationhood (Department of Education, 1997).

This new curriculum, C2005, was characterized by very complex logic and vague content, with Taylor and Vinjevold (1999) claiming that it appeared to promote superficiality at the expense of systematic and grounded conceptual development.

Curriculum 2005 was reviewed in 2000 by a team led by Professor Linda Chisholm. The review report was initially viewed as being extremely controversial by the African National Congress (ANC) key players, viz. the Minister of Education, the South African Democratic Teachers' Union, Departments of Education and Cabinet (Chisholm, 2003). The relative independence of the Review Committee members from the government allowed the task team to differ from the views and approaches dominant within the bureaucracy and the teacher unions.

Ultimately, Cabinet accepted the recommendations and a 'middle ground' around outcomes-based education was found, where the key role players united around the need for a secular, liberal humanist, rights-based curriculum that recognised the diversity of South Africans. Curriculum 2005 was simplified, refined and strengthened, and a Revised National Curriculum Statement was produced in 2002 (Grades 0 to 9), with the final National Curriculum Statement (NCS) for the General Education and Training band being passed in 2007.

## 3.1 Rationale and philosophy

The Constitution of the Republic of South Africa, 1996 (Act No 108 of 1996) provides the basis for curriculum transformation and development in contemporary South Africa. The State's Manifesto on Values, Education and Democracy (Department of Education, 2002) promotes the idea that values should provide direction for the application of knowledge and skills in all learning areas in all grades. It further identifies strategies for familiarising young South Africans with the values of the

Constitution. These strategies find expression in the Revised National Curriculum Statement/National Curriculum Statement (R/NCS). These statements include "ensuring equal access to education" (Department of Education, 2002, p. 7; 2007, p. 7), and "freeing the potential of girls, as well as boys" (Department of Education 2002, p. 8; 2007, p. 8) as a priority.

This study evolved out of my concern over what I have perceived as poor self-efficacy, indifference towards values in education and towards notions of excellence amongst my students. As the students and I worked together to accomplish our goal of using values to promote mathematical self-efficacy and excellence in teaching and learning, I trusted that fresh ideas and practices would emerge, and that I could impart a sense of vitality in mathematics education classes, and thereby honour the complexity of teaching and learning.

The RNCS and NCS policy documents state that "being mathematically literate enables persons to contribute to and participate with confidence in society". The mathematics learning area statement of this document follows from the above statement. It states that "access to Mathematics is, therefore, a human right in itself" (Department of Education (2002, p. 4; 2007, p. 4). The outcomes and assessment standards leave "considerable room for creativity and innovation on the part of teachers in interpreting what and how to teach" (Department of Education, 2002, p. 12; 2007, p. 12).

According to the overview of the R/NCS (Department of Education, 2002, p. 10-11; 2007, p. 10-11), "both the process and the content of education are emphasized by spelling out the outcomes to be achieved at the end of the process". Spady (1994) explains that outcomes are actions and performances that embody and reflect learner competence in using content, information, ideas and tools successfully. It is required

that learners should be able to demonstrate their knowledge in measurable actions. The R/NCS supports the philosophy that "outcomes encourage a learner-centered and activity-based approach to education" (Department of Education, 2002, p. 1; 2007, p. 1). As such, teaching and learning, according to this particular philosophy of outcomes, may be seen to concur with philosophies which underpin constructivism and inquiry-based education.

## 3.2 Critical and Developmental Outcomes

The critical and developmental outcomes of the R/NCS, which underpin the rationale and the philosophy of the curriculum statement, are derived from the Constitution, and are contained in the South African Qualifications Act (1995). They describe the kind of citizen the education and training system should aim to uphold – so that learners would be able to develop into responsible citizens of the 21st century (Department of Education, 2002; 2007).

The National Curriculum Statement attempts to embody and uphold a democratic vision of the society and the citizens that should emerge from our school system. The critical outcomes listed below envisage learners who will be able to:

- Identify and solve problems and make decisions using critical and creative thinking;
- Work effectively with others as members of a team, group, organisation and community;
- Organise and manage themselves and their activities responsibly and effectively;
- Collect, analyse, organise and critically evaluate all information;
- Communicate effectively, using visual, symbolic and/or language skills in various modes;

- Use Science and Technology effectively and critically, showing responsibility towards the environment and the health of others;
- Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

In turn, the developmental outcomes of the Revised National Curriculum Statement (Department of Education, 2002) envisage learners who are also able to:

- Reflect on and explore a variety of strategies to learn more effectively;
- Participate as responsible citizens in the life of local, national, and global communities;
- Be culturally and aesthetically sensitive across a range of social contexts;
- Explore education and career opportunities;
- Develop entrepreneurial skills.

The critical and developmental outcomes noted above support and concur with the philosophy of constructivism and inquiry-based education. The mathematics learning area, as described in the R/NCS (Department of Education, 2002; 2007), includes interrelated knowledge and skills which allow for the development of skills and mastery within constructivism and inquiry-based education approaches.

## 3.3 Learning Outcomes and Assessment Standards

The learning outcomes of the National Curriculum Statement are derived from the critical and developmental outcomes previously described. The learning outcomes and assessment standards express the minimum requirements and expectations of learners at each Grade level. According to the R/NCS (Department of Education, 2002; 2007), learning outcomes and assessment standards are cognitively dependent and supportive of each other. As noted previously, the outcomes and assessment standards emphasise participatory, learner-centered and activity-based education, and leave

considerable room for creativity and innovation on the part of teachers in interpreting what and how to teach (Department of Education, 2002; 2007).

Also, the NCS emphasises "the importance of learning support materials and teacher-development programmes to interpret and give expression to the learning outcomes and assessment standards" (Department of Education, 2002, p. 15; 2007, p. 15). The learning outcomes emphasize the importance of using a range of teaching and learning strategies in a variety of contexts. This approach is also promoted by constructivism and inquiry-based education.

## 4. TRADITIONAL, CONSTRUCTIVIST AND INQUIRY APPROACHES

As the South African National Curriculum is underpinned by notions of constructivism and inquiry-based learning (Moll, 2002), understandings considered to be traditional, constructivist and inquiry-based approaches will be considered in this section.

### 4.1 Traditional approaches to teaching

A traditional approach is characterised by teachers who disseminate knowledge in a situation where student-initiated questions and student-to-student interactions are atypical (Brooks & Brooks, 1993). Most teachers rely heavily on textbooks; and the information teachers disseminate to students is directly aligned with the information offered by textbooks, providing students with only one view of complex issues and one set of truths. This unilateral approach often devalues student thinking (Brooks & Brooks, 1993). "Schooling is premised on the notion that there exists a fixed world that the learner must come to know. The construction of new knowledge is not as highly valued as the ability to demonstrate mastery of conventionally accepted understandings" (Layman, 1996, p. 7).

Llewellyn (2005) describes a traditional classroom setting in which students usually sit in straight rows of desks and learn through rote memorisation. Students must listen attentively to the teacher, who usually stands in the front of the room 'imparting' information, while the students passively take notes from the board. The lesson is structured around 'teacher-talk' and student responses. A single textbook usually guides the teacher's presentation. Llewellyn further believes that many teachers view learners as passive participants with a need to know and master a fixed body of information.

The traditional approach is interpreted as being authoritarian, an aspect which, in the South African context, has been attributed to the adoption of Fundamental Pedagogics by the Education Department during the Apartheid era (Chisholm, 1993; Hartshorne, 1992; Hofmeyr, 1993). According to Taylor and Vinjevold (1999), traditional education requires little more of learners than passive obedience, and to be passive recipients of knowledge. This traditional approach does not really help learners to construct a sense of moral self-worth. To do that, they need opportunities to participate in class discussions on values (Nieuwenhuis, 2007). Nucci (1997) claims that moral discussion and moral problem-solving foster moral development. Moral reasoning develops when learners recognise inconsistencies and inadequacies in their present moral positions (Berkowitz, 1995).

## 4.2 Constructivism

According to Llewellyn (2005), constructivists do not view the mind as a 'blank slate' or an 'empty vessel', as in John Locke's famous expression *tabula rasa*. In the constructivist approach, the student is an active participant in the learning process. Constructivism is a theory whereby we come to know what we know (Llewellyn, 2005). It is founded on the premise that learners construct or make meanings about the world around them – based on the context of their existing knowledge. From a constructivist

point of view, according to Llewellyn (2005), the learner is constantly filtering incoming information based on his or her existing conceptions and preconceived notions – to construct and reconstruct his or her own understanding.

Thus, the meaning of 'knowing' is an active, adaptive and evolutionary process. Although literature expounds many types of constructivism (Ernest, 1995), all seem to embrace the basic principle that "learning is not a passive receiving of ready-made knowledge, but a process of construction, in which the students themselves have to be the primary actors" (von Glasersfeld, 1995, p. 20).

Rather than passively receiving and recording information, learners actively interpret and impose meaning through the lenses of their existing knowledge structures. Berger (2008) asserts that if we want youth to learn how to work effectively with diverse others and to participate meaningfully in the shared construction of knowledge, then we need to give them opportunities to engage with one another through dialogue and through the production of work that matters.

According to Webb and Glover (2004), learners construct meanings of what they see and hear by generating links between what they already know and the new things they experience. They further explain that the idea that we construct meaning suggests that it is not so much what we get out of a situation, but what we bring to it that determines the sense of what we are going to make of it.

Pastoll (2002) emphasizes the need to revolutionise the basis on which students are enticed to convert energy into learning. To do this, he advises that we discard many traditional teaching methods in favour of learning activities, in which students can feel the power of intrinsic motivation, the kind which comes from direct enjoyment of the activity of learning.

This research study is characterised by negotiation, feedback and mutual respect, while this constructivist perspective has added a further dimension to my thinking on teaching and learning. As such, I attempt in my own classes, to maximize on activities and opportunities which support constructivist principles.

*The philosophy underpinning constructivism*

As mentioned earlier, constructivism embraces the basic principle that "learning is not a passive receiving of ready-made knowledge, but a process of construction in which the students themselves have to be the primary actors" (von Glasersfeld, 1995, p. 120). Llewellyn further describes constructivism as a philosophy on how an individual learns, one in which the student is embedded in active engagement and is constantly constructing and reconstructing knowledge through interaction with his/her environment.

Constructivism is underpinned by the belief that children acquire knowledge as they actively engage in the construction of knowledge. According to Piaget (1973), to understand is to discover or reconstruct by the process of rediscovery, and such conditions must be complied with – if in the future individuals are to be capable of production and creativity – and not simply repetition and recall.

Based heavily on the work of Piaget, constructivism guides teachers to interact with learners through questioning and discussion, skilfully responding to learners' ideas, and allowing children to discover relationships and predict future events. Learners engage in manipulating materials, playing games and interacting with one another (Sheffield & Cruikshank, 1996). "A constructivist framework challenges teachers to create environments in which they and their students are encouraged to think and

explore. This is a formidable challenge. But to do otherwise is to perpetuate the ever-present behavioural approach to teaching and learning" (Brooks & Brooks, 1993, p. 30).

*Constructivism and the South African National curriculum statement*

Current mathematics educational reforms, supporting a constructivist perspective, suggest that the automation of skills and passive intellectual involvement should be replaced by active learning processes (Hiebert, 1992). Glenda Anthony (1996), in her article entitled, *Active Learning in a Constructivist Framework*, defines 'active learning' as learning activities in which students are given considerable autonomy and control of the direction of the learning activities.

Learning activities commonly identified in this manner include investigational work, problem solving, small group work, collaborative learning and experiential learning. In contrast, Anthony describes 'passive learning' as denoting learning activities in which the students are passive receivers of information. This 'passive learning' would include listening to the teacher's exposition, being asked a series of closed questions, and the practice and application of information that has already been presented.

This means that mathematics is most effectively learned through students' active participation in mathematical situations, rather than through passive acceptance and the repetition of knowledge (Ministry of Education, 1992). The R/NCS states that outcomes-based education forms the foundation of the curriculum in South Africa. The outcomes encourage a learner-centered and activity-based approach to education. Inquiry-based teaching and learning – which are underpinned by constructivism – are, therefore, hugely promoted by the South African national curriculum.

Herrington (1990) further supports the view that the active nature of learning, encouraged by curriculum documents, is aligned with the active mental experiences, which result in strong acts of construction if students are to learn the desired mathematical concepts.

### 4.3 Inquiry-based learning

Llewellyn (2005, p. 27) highlights the point that constructivist learning strategies are compatible with inquiry and learner-centered classrooms. This author holds that "a prerequisite for becoming an inquiry-based teacher is embracing a philosophical mind-set founded on the ideals and principles of constructivism". Because the tenets of constructivism align closely with the practice of inquiry, it becomes essential that inquiry-based teachers themselves have a firm foundation in the propositions of constructivism.

Inquiry-based learning is supported by the findings of Piaget and Vygotsky (Engel, 1996). Piaget viewed learning as an internally driven process, an individual construction, which results from learners engaging in the world, whereas Vygotsky argued that learners acquire knowledge in the course of social relationships (Moll, 2002; Western Cape Department of Education, 2000). The learner does not construct his/her own knowledge independently, but finds that learning occurs on a social level, and within a particular cultural context (Moll, 2002; Western Cape Department of Education, 2000).

According to Llewellyn (2005), these interpretations of constructivist principles facilitate a better vision of the role of inquiry-based teachers. Layman (1996) describes inquiry-based learning as an ongoing process that is continually encouraging students to translate new experiences and concepts into workable solutions through

experimentation. Through leaps of insight, trial and error, argumentation, and frustration, students apply the concepts of mathematics (or any other discipline) to expand what they know and what they are able to do. Cronen (2001) notes that single explanations blind the inquiry process to any alternatives, while Weick (2007) argues that creating rich explanations, accounts, and readings of situations are important elements of theorizing.

Layman (1996) points out that inquiry-based teachers should be constantly aware of shifting the onus of responsibility from the teacher to the student, thereby enabling the student to become a more independent learner.

*Concerns regarding present mathematics teaching*

According to Maree and Fraser (2004, p. 6), "…teaching and learning were, and still are, very much content-based in a significant number of schools in South Africa. The focus of content-based learning is on prescribed syllabi which learners must master." Maree and Fraser further explain that traditional and content-dominated teaching and learning seldom relate to real-world demands and real-life experiences. In terms of the 1995 White Paper on Education and Training, last modified in 2008, the need for major changes in education and training in South Africa was emphasized in order to transform teaching and learning and realize the ideal of "excellence for all".

Cole and Knowles (2000) observe that in most educational research involving students, the focus has been traditionally on their performance achievement, motivation, cognition or affective development, but very little attention has been given to how students actually experience school, learning and teachers. Cullingford (1987) believes that teachers are naturally tempted to feel that education is a one-way process.

In this research study, I have learnt the value of involving students as vital sources of information and insight on teaching, learning and university education.

*Implications for teacher development*

The R/NCS overview policy document emphasizes the need to transform teaching and learning in South Africa and shift away from the traditional aims-and-objectives approach to outcomes-based education (Department of Education, 2002; 2007), the characteristics of which underpin inquiry-based teaching and learning. According to Drayton and Falk (2001), inquiry is not a matter of process-versus-content; but rather, it is a way of learning content. Llewellyn (2005) supports these implications for teacher development, and asserts, as mentioned earlier, that an understanding of constructivist principles would enable a better vision of their role as inquiry-based teachers.

Current mathematics education reforms supporting a constructivist perspective suggest that the automation of skills and passive intellectual involvement should be replaced by active learning processes (Hiebert, 1992). According to Anthony (1996), 'active' learning denotes learning activities in which students are given considerable autonomy and control of the direction of the learning activities, such as investigational work, problem solving, small group work, collaborative learning and experiential learning.

In contrast, 'passive' learning activities denote learning activities in which students are passive receivers of information, and include listening to the teacher's exposition, being asked a series of closed questions, and the practice and application of information already presented. The R/NCS concurs with the active learning process in

that it states that the mathematics learning area develops an ability to engage in the process of inquiry and investigation (Department of Education, 2002; 2007).

Llewellyn (2005) asks how we can expect our students to engage in inquiry-based activities if we, as teachers, do not have a sufficient understanding of inquiry-based thinking ourselves? He believes that teachers should be able to articulate, in detail, their understandings, attitudes and dispositions with regard to being an inquiry-based teacher. He further describes inquiry as a personal and professional journey that starts with developing a constructivist-based philosophy, and reflecting, both individually and with others, on instructional beliefs and practices.

He encourages teachers to journey further into their understanding of inquiry, in order to realize how inquiry-based classrooms promote critical thinking skills and empower students to become independent, life-long learners (Llewellyn, 2005). Pastoll (2002) reminds us that teachers create the emotional situation in the classroom and that teachers therefore, need to create a classroom atmosphere that is conducive to inquiry-centered teaching and learning.

Layman (1996) advocates that inquiry-centered instruction be described in terms of a set of characteristics shared by teachers adopting this approach. Such teachers:

- Encourage and accept student autonomy and initiative
- Use raw data and primary sources, along with manipulative, interactive, and physical materials
- When framing tasks, use cognitive terminology such as classify, analyse, predict and create
- Allow student responses to drive lessons, shift instructional strategies, and alter content

- Familiarise themselves with students' understandings of concepts before sharing their own understandings of those concepts
- Encourage students to engage in dialogue, both with the teacher and with one another
- Encourage student inquiry by posing thoughtful, open-ended questions and asking students to question each other
- Seek the further elaboration of students' initial responses
- Engage students in experiences that pose contradictions to their initial hypotheses, and then encourage discussion
- Allow time after posing questions
- Provide time for students to construct relationships and create metaphors
- Nurture students' natural curiosity

(Brooks & Brooks 1993, pp. 101-118)

According to McKenzie (2004), the success of an inquiry classroom comes from a shift in the teacher's role from the 'sage on the stage' to the 'guide on the side'. He emphasizes the need for the classroom environment to shift from teacher-centeredness to learner-centeredness. Hewson (1996) suggests that teachers allow students to become active participants in class, but emphasises the need to create a balance between the teacher's views and discovery learning. According to Bruning et al. (1995), it is important that, in order to encourage learning, teachers reveal learners' preconceptions and create cognitive conflict between the learners' current conceptions and the new concepts that need to be learnt.

When students are involved in building their classroom community, they must be empowered and feel that their ideas count – this is the foundation of inquiry-based learning. Brooks and Brooks (1993) emphasize the importance of seeking to understand students' points of view. They describe students' points of view as windows into their reasoning and hold that valuing students' points of view means not only recognizing

them, but also addressing them, making school experiences both contextual and meaningful. Llewellyn (2005) holds that inquiry involves active explorations by students in which they use critical, logical and creative thinking skills to raise and engage in questions of personal interest. Inquiry-based activities are driven by students' curiosity and students in inquiry-based classrooms are expected to take responsibility for their own learning.

The characteristics of traditional and inquiry-based classrooms can be differentiated by examining three areas: what the classroom looks like; what the students do; and finally, what the teacher does (Llewellyn, 2005). Inquiry-based classrooms are described as being learner-friendly, where learners feel that their teacher and peers value their ideas, thoughts and opinions. The classroom provides opportunities for active involvement in the learning process. Styles of presentation, organisation, questioning skills, and even body language seem to differ from those observed in traditional settings.

The National Science Education Standards (1996) assert that students must take responsibility for their learning, and teachers must create opportunities for them to do so, individually and as members of a group. The NSES suggests that teachers can do so by supporting students' ideas and encouraging their questions. Teachers must give individual students active roles in the design and implementation of investigations, in the work with their peers, and in students' assessment of their own work (National Research Council, 1994, p. 36).

*Overcoming the legacies of the past*

As noted earlier, there is broad consensus that teaching and learning in the majority of South African schools still focuses on teacher-centeredness, pupil passivity

and rote learning, a practice which is problematic worldwide, but which is particularly true in South Africa because of the historical legacy of past political practice. Callier (2008) believes that inadequate understanding of our past has had destructive consequences for education. He asserts that the cost to education has been high and we need to reclaim the professional integrity and vitality of teaching.

Intrator and Kunsman (2009) refer to *vocational vitality*. This includes an engrossment in one's work that is marked by a sense of dedication to the belief that the work is meaningful and purposeful. It includes a commitment to one's labours that organisational theorist William Kahn (1990) describes as being 'fully there'.

In 1958 Stephen Coley, former professor of education in the USA made an observation as internationally relevant today as it was five decades ago. He remarked, "I can imagine no more significant single indication of the vitality of teacher education than the existence of a tremendous amount of experimentation and testing of new and promising ideas. This, it seems to me, we ought to be doing much more of" (Coley, 1958, p. 439). Fraser (2005) reminds us that "regulation may provide a floor that eliminates some bad teacher training programmes, but it also provides a ceiling that limits experimentation and new forms of excellence" (p. 283). He advises, that in the quest for a vibrant teacher education programme it is now time to consider constructive approaches that may contribute towards revitalising teacher education.

Caillier and Riordan (2009) emphasize the importance of teacher education programmes, where there is a reciprocal relationship between teacher education and school reform, insisting that if teacher education is to play a role in changing schools, it must itself change.

The South African National Curriculum Statement describes mathematics as a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. Through this process, new mathematical ideas and insights are generated. This definition of mathematics given by the South African government supports current thinking on how learners learn best.

The implementation of inquiry-based education and constructivism is the required approach to developing learners who will meet the learning outcomes and assessment standards of the National Curriculum Statement.

The South African National Curriculum Statement is grounded in outcomes and the achievement of these outcomes. However, I soon realised that these outcomes are not an end in themselves, and that I needed to move my thinking away from measuring outcomes to assessing outcomes according to the improved learning that has taken place. This realisation required that I clearly consider what this 'improved learning' is that I want to take place; what values I wish to instil; and what notions of excellence I want to engender.

The descriptions above, relating to the implications of constructivist and inquiry-based teaching and learning, frame my understandings of how and what type of teaching and learning should take place and provide indicators of excellence. The following section on values in education elaborates on notions of the type of moral values that help engender excellence, and promote a desire in students to attain excellence.

## 5. VALUES IN EDUCATION

According to Nieuwenhuis (2007), there has been an internationally renewed interest in values and morals in education. He asserts that although theorists differ on whose values and what values should be included, there is general agreement that values are important concerns that education institutions will have to deal with if they are serious about issues of quality and effectiveness.

Nieuwenhuis challenges education to inculcate the values associated with a 'good citizen', since values are consciously and unconsciously at work in all our interpersonal interactions and form a basis and an integral part of all human actions, thus making education by its very nature a value-based and value-laden phenomenon.

According to the National Curriculum Statement, South Africa has accepted the challenge of inculcating values associated with being a 'good citizen', as one of the key objectives of the critical outcomes, described earlier. This involves the need to develop responsible citizens for the 21st century.

Feiman-Nemser and Remillard (1996) define teaching as the work of helping people learn 'worthwhile things', which, as they point out, adds an explicitly moral dimension to the enterprise. This is affirmed by Ball and Forsani (2009) who assert that decisions about what to do are not appropriately rooted in personal preferences or experiences, but are instead based on professionally justified knowledge, and on the moral imperatives implicit in the role of teaching.

### 5.1 Values, morals and ethics

Nieuwenhuis (2007) explains that since literature on values is commonly tied to specific intervention programmes it creates the impression that value-related concepts are interchangeable or synonymous. However, the terms *values, morals,* and *ethics* are

not the same, but they do share common elements. Considering the fundamental roots of the word *value* in its Latin (valere) and old French (valior) contexts, it is clear that the concept of a value refers to that which is worth striving for and what the individual sees as worth protecting, honouring and desiring. The principles or standards of human conduct are called morals, which have roots in the Latin word *mores* meaning customs, while ethics is considered to be a code of behaviour based on such moral principles.

According to Kidder (2006), there are core-moral values that are cherished around the world – respect, fairness, responsibility, honesty and compassion. These core-moral values concur with the five values adopted by the Faculty of Education at NMMU and are used in this research study. However, this research study uses the word 'accountability' rather than responsibility. Kidder notes that values involve both the processes of intellectual discourse and the feelings of rightness and wrongness inherent in each individual. Nieuwenhuis (2007) emphasizes that we cannot give values to others, we can only impart our values by setting an example, as values are more readily "caught than taught".

He advocates that all meaningful human behaviour becomes a manifestation of the value system at work, and any behaviour that is contrary to our personal value system creates tension and feelings of uneasiness. He argues that we choose our behaviour based on our personal and socially constructed values, assumptions and beliefs, which in turn, inform our understanding of what is morally right and morally wrong – and of the type of conduct that would be labelled as just and ethical (Nieuwenhuis, 2007).

Scholarly debate on moral development and character formation extends at least as far back as Aristotle's *Nichomacean Ethics* and Socrates' *Meno,* and continues

through to modern times (Nucci, 1989). For most of history, the concept of character formation has been a basic principle structuring moral education. According to Nieuwenhuis (2007), the values debate is sure to continue, as educationists and decision makers grapple with issues of human rights, moral decay, a lack of school discipline, and a breakdown in the culture of teaching and learning in schools.

## 5.2 Promoting values in education

As mentioned, governments from all over the world are currently engaged in the quest to implement a pedagogy that can provide the range of knowledge, skills and attitudes for generational change in schools and institutions of higher education. Lovat et al. (2008) describe how Moral Education took centre stage at the Australian Values Education Conference which promoted the notion of re-inserting a focus on humane education as a pedagogical imperative.

The Australian Values Education Programme rests explicitly on the concept that best-practice pedagogy is inherently a moral and humane issue, as well as an intellectual endeavour. As mentioned previously, the South African Manifesto on Values, Education and Democracy promotes the idea that values should provide direction for the application of knowledge and skills in all the learning areas of the national curriculum.

Nelson Mandela, as quoted in the Department of Education's manifesto on values, human rights and democracy (2002), reminded us that we could not take the values enshrined in the Constitution for granted, and stated that our younger generation need to make values a part of their innermost being. The authors of this Manifesto (DoE, 2002) question whether we have lost touch with the fundamental values that actually drive our democracy.

Nieuwenhuis (2007) suggests that we have allowed ourselves to become buried in an avalanche of policies, programmes, priorities, and personal agendas, and have forgotten that the core goal of education is: to free the potential of all young South Africans by imparting to them the knowledge, skills and values that will make them effective, productive and responsible citizens.

Nucci (1997) states that to think that values can be taken out of education is about as senseless as stating that our bodies should not be allowed to contain bacteria. Nieuwenhuis (2007) argues that if values were to be taken out of education, the possibility of truly human interaction would cease to exist. He asserts that values are a natural part of what education is all about; and he believes that many adults and educationists consider modern educational institutions to be at fault, because there is an absence or lack of a strong-enough focus on the crucial role that education should play in promoting acceptable social values.

The global moral degeneration with its elements of teenage pregnancy, violence, family disintegration, drug abuse, etc. is seen as a call on educationists to address these problems by reinstating good, old, solid traditional values (Heenan, 2003). The Manifesto describes *Ubuntu* (human dignity) as a culturally based value rooted in a specific conception of what it means to be human. For this reason, it is intricately linked to human values and practices, such as love, respect, peace, honesty and integrity and is encapsulated in the value of human dignity.

According to Nieuwenhuis (2007), discussing and debating values and human rights in the classroom provide educators with the opportunity to clarify concepts within the socio-cultural milieu of the classroom and the community. Nieuwenhuis (2007) believes that values need to be clarified, discussed, refined and re-invented through a

process of active deliberation of values and ethical issues. Actions flowing from value-based discussions should be directed at enabling students to impart meaning to the values, and to learning how to act consistently according to their values.

He believes that learners develop moral reasoning when they recognise inconsistencies and inadequacies in their moral positions. Once they have knowledge of conflict resolution and social problem-solving they are able to engage in non-confrontational peer interactions.

*Core values*

Kidder (2006) refers to these same values as moral values which constitute humanity's common moral framework. Based on research conducted by the Institute for Global Ethics, these core values are acknowledged as "the core moral and ethical values held in highest regard in diverse communities around the world, given the global diversity of culture, ethnicity, race, religion, gender, political persuasion, economic disparity and educational attainment" (p. 42-43).

Fagan (2003) agrees that there exists a rationally identifiable moral order that traverses cultural, historical and other boundaries, and which focuses on the imperative duty placed on the individual regarding his or her interaction with others. According to the philosopher W.D. Ross (Cooley, 2005), our duties are grounded in the value system of society. The challenge of the South African mission statement of the Department of Education (1996, p. 1) was articulated as follows: "Our vision is of a South Africa in which all people have equal access to lifelong education and training opportunities which will contribute towards improving the quality of life and build a peaceful, prosperous and democratic society".

The policies and legislation developed during this period had to, as stipulated in the Constitution of 1996, give positive recognition to and promote the values of human dignity, equality, human rights and freedom, non-racism access to basic education for all.

Reviewing a broad range of scholarly work on universal values, Yale sociologist Wendel Bell (cited in Kidder, 2006) noted that the path toward a harmonious global society and moral community is well marked by widely shared human values. Kidder also asserts that "there is indeed a core of shared values, widely held across numerous cultures, that appears to express itself through the five moral ideas of honesty, fairness, respect, responsibility and compassion" (Kidder, 2006, p. 64). Nieuwenhuis (2007) concurs with Kidder and Bell, as he believes that in most classroom communities a core set of values acts as the main deciding factor in directing the actions and behaviour of community members to what is appropriate.

Hill (1988), however, warns that even if students provisionally accept and believe in the value being discussed, there is no guarantee that intellectual belief will automatically imply commitment to live by that belief.

*Ethics and Morals*

Though codes of ethics may not have played a significant role in teacher-preparation programmes in the past (Strike & Ternasky, 1993), the professional ethical disposition of teachers in the USA must now be addressed as part of the National Council for the Accreditation of Teacher Education's (NCATE) accreditation process (NCATE, 2002). A programme of ethical education developed for dental professionals at the University of Minnesota, is now finding adaptations to other professional training programmes, including the training of teachers (Rest & Narvaez, 1994).

In South Africa, the South African Council of Educators' code of conduct defines an educator as someone who "strives to enable learners to develop a set of values consistent with those upheld in the Bill of Rights, as contained in the Constitution of South Africa" (SACE, 2001).

It appears that moral and ethical issues, including character education, are gradually being integrated into many of the teacher-education programmes, both nationally and internationally. Deans and administrators of teacher-education programmes agree that core values can and should be taught in our schools and teacher-preparation classes (Nieuwenhuis, 2007). Caillier and Riordan (2009) believe that there is a reciprocal relationship between teacher education and school reform, insisting that if teacher education is to play a role in changing schools, it must itself change. It is now up to the teaching profession and teacher educators to ensure broader and deeper implementation of these important issues in the practical situations.

*Rationale for including values in this study*

During the course of more than a decade of university lecturing, I have been aware of certain behaviours amongst students that concern me. Since 2007, and the inception of the revised university education course curriculum, students who had selected the language, rather than the mathematics option, for their B Ed degree course were compelled by curriculum design to register for one mathematics education course during their studies. During my initial lectures with the 'language-option' students, it was clear from their body language and negative attitudes that they were not at all enthusiastic about participating in the mathematics education lectures.

In 2009 I interviewed both 'mathematics and science option' (n=79) and 'language option' (n=51) students registered for my mathematics education classes

before the commencement of semester lectures. The ‘language-option’ group of students was generally open about the fact that they were attending mathematics education classes under duress, and many of them were obviously hostile to the idea of having to participate in mathematics education classes for the duration of one semester. Considering these students’ negativity towards mathematics education I was concerned that these students’ attitudes and behaviours would inhibit the development of the values and professional ethics that I believed should be part of their professional preparation.

As part of this study, once the pre-intervention focus-group interviews and the affective-disposition statement responses had been completed by the students, the Director of the Centre for Research, Technology and Innovation within the Faculty of Education of the Nelson Mandela Metropolitan University addressed all the students participating in this research study. He introduced them to the ‘values wheel’, which, he explained, had been formulated and accepted by the Faculty of Education staff members after a series of staff-development workshops.

He explained how this research study was informed and underpinned by the core-values of respect, fairness, accountability, honesty and compassion, and that these values revolved around the notion of trust, and were bound together by a ring of integrity. Discussions which followed enabled the students to clarify their own thinking on these values, and the possible influence of implementing a values-based approach to the teaching and learning in mathematics education.


*Figure 2.1:* The Values Wheel developed by the Faculty of Education at the NMMU in 2008

## 6. SELF-EFFICACY

The Roman poet Virgil (70-19BC) observed in his epic poem, '*The Aeneid*' that 'they are able who think they are able'. The 19th century French novelist, Alexander Dumas, wrote that, when people doubt themselves, they make their own failure certain by themselves being the first to be convinced of it. There is now overwhelming evidence to suggest that Virgil and Dumas were correct (Bandura, 1994; Nicolaidou & Philippou, 2003). In encouraging my students to teach, by using constructivist and inquiry-based approaches within a framework of core values aimed at the pursuit of excellence, I believed that I could enable them to overcome the self-doubts that appeared to be so common amongst my mathematics education students.

Hoy (2004) describes self-efficacy as a belief in one's ability to successfully accomplish a particular task; while Bandura (1994) advocates that a strong sense of

efficacy enhances human accomplishment and personal wellbeing. He explains that people with high assurance levels in their capabilities approach difficult tasks as challenges to be mastered, rather than as threats to be avoided. In contrast, people who doubt their capabilities shy away from difficult tasks which they view as personal threats, and they have low aspirations and weak commitment to the goals they choose to pursue.

Bandura further believes that self-efficacy can be influenced through social persuasion, where people are persuaded verbally that they possess the capabilities to master given activities to the extent that a persuasive talk may lead to people exerting more effort to succeed.

Bandura (1994, p. 2) cites "mastery experiences" as the primary source of self-efficacy – and also the most effective manner in which to enhance self-efficacy. He also notes that peoples' level of self-efficacy is dependent on their "somatic and emotional states in judging their capabilities. These states include the person's levels of anxiety, stress, arousal and fatigue. Consequently, if one is to improve a person's self-efficacy, it is important to promote a positive mood in the person, remove stress and alter any negative emotional feelings and interpretations of their own wellbeing".

I therefore attempted to create a classroom climate in which all the students (and I too) felt valued, and which would be conducive to promoting students' self-efficacy in mathematics education. Given the backdrop of South Africa's poor achievement in mathematics, I accepted the challenge to improve the mathematics self-efficacy of our initial teacher education students – who were registered for the mathematics education course (PICM 201) at the Nelson Mandela Metropolitan University.

This has necessitated cyclical planning and creative implementation strategies – in order to comprehend and motivate students both cognitively and socially. Pastoll (2002) reminds us how rapidly we forget the content of our studies, while memories of our disposition toward the subject persist.

## 6.1 Believing the best of others

Bandura (1994) advocates that people who are persuaded verbally that they possess the capabilities to master given activities are likely to mobilize greater effort in order to succeed, thus promoting the development of skills and a sense of self-efficacy. He further suggests that successful efficacy builders should structure situations for others in ways that bring success, and avoid placing people prematurely in situations where they are likely to fail. Students need to measure their success in terms of self-improvement rather than by triumphing over others.

Nicolaidou and Philippou (2003) concur with Bandura's philosophy, as they claim that a person's behaviour and choices, when confronted with a task, are determined more by beliefs and personal theories rather than by knowledge of the specifics of the task. The authors further cite Bandura, who reaffirms the fact that "self-efficacy is a major determinant of the choices that individuals make, the effort they expend, the perseverance they exert in the face of difficulties, and the thought patterns and emotional reactions they experience" (Nicolaidou & Philippou, 2003, p. 3).

I took Bandura, Nocolaidou and Philippou's advice seriously, as I attempted to implement classroom strategies which would have the desired results. I accepted the challenge of improving the academic learning and confidence levels of the students in my mathematics education classes.

Pastoll (2002) makes mention of a research study to investigate the motivational forces of top achievers in various fields of study. The single most dominant factor was that every single one of these people had had a significant adult who believed in them and exuded a quiet confidence in their capabilities and prospects. Pastoll further encourages all educators to focus on what students can do, and not to dwell on what they cannot do.

In summary, perceived self-efficacy is concerned with people's confidence in their capabilities to exercise control over their own functioning and over events that affect their lives. Beliefs in personal efficacy affect life choices, levels of motivation, quality of functioning, resilience to adversity, and vulnerability to stress as well as to depression (Bandura, 1994).

## 6.2 Teacher efficacy and teacher self-efficacy

Dellinger (2001) concurs with Bandura's (1997) explanation of the distinctly different constructs between teacher efficacy and teacher self-efficacy. The construct, teacher sense of efficacy (later shortened to teacher efficacy), was named, defined and measured in the mid-1970s by two groups of researchers from the RAND Corporation (Armor et al., 1976; Berman & McLaughlin, 1977). Teacher efficacy is defined as teachers' beliefs in their own abilities to affect student performance, while teacher self-efficacy beliefs focus on successfully performing the specific teaching tasks in a teacher's current teaching situation.

Self-efficacy beliefs are task- and situation-specific; thus, efficacy beliefs are not considered to be the trait of an individual (Bandura, 1997; Maddux, 1999), but rather an active and learned system of beliefs held in context (Dellinger et al., 2008).

### 6.3 Self-efficacy as an indicator of successful practice

As previously noted, self-efficacy is one's belief in one's own ability to perform an action with confidence. In the case of this study, this relates to students' belief in their ability to do mathematics with confidence and enjoyment. Pajares (2002) advocates that highly regarded teachers who model excellence in their teaching can use their educational influence to encourage self-belief in students and promote personal self-efficacy. It may, therefore, be argued that an evaluation of student self-efficacy in mathematics education provides a pertinent indication that can be used when considering the effect of any practice – my own, and that of others.

## 7. NOTIONS OF EXCELLENCE

Landmark Education (2010) notes that:

> *Excellence is not a matter of ability, knowledge or practice. It cannot be taught, imposed, or wished into existence. Excellence is a matter of the stand we are and the stand we take – a stand that allows for performance that surpasses what was previously possible, performance that defies old limits and maps new territory.*
>
> (Landmark Education, 2010)

Aristotle wrote about the development of excellence, stating that to become excellent at any craft, including becoming virtuous, we have to exercise those behaviours. He stated that we become just by the practice of just actions, self-controlled by exercising self-control, and courageous by performing acts of courage. Woolfolk (2004) claims that we will never have the perfect curriculum or teaching strategy, but teachers who set high goals, who persist, who try another strategy when one approach is found wanting – in other words, teachers who have a high sense of efficacy themselves

and act on it – are more likely to have students who experience success and learn that effort pays off.

Hess (2005) supports Woolfolk's claim and encourages teacher educators to "construct a system that fosters excellence" (p. 192).

Pastoll (2002) describes a person's 'sense-of life' as one's energy, ability to focus, breadth of vision, range of interests and sense of humour. Pastoll believes that the benchmark for excellence in teaching is a process which energises, animates and inspires learners; and he further suggests that building good relationships, having stimulating conversations, and doing activities with students that interest them are ways of promoting excellence, without resorting to grading and labelling students. He advocates that merely by doing these and other activities we gain confidence and motivation, and remove some of the obstacles to developing excellence. He warns that students see a teacher's 'sense-of-life' more vividly than they see their own status, age or anything the teacher may be trying to teach them. Teachers' 'sense-of-life' can either be an inspiration or a very bad example. Students can then choose either to emulate or withdraw from the example given by a teacher's personal style.

The 2020 vision statement of the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth, where this research study took place, states that the key objective is to place the university on a growth path to achieve excellence in respect of the core mission of: teaching, learning, research and engagement (see NMMU website www.nmmu.ac.za). This research study, therefore, supports the realisation of the university vision.

## 8. COMPLEX LEARNING COMMUNITIES

A complex system is seen as something greater than the sum of its parts; it is the product of the parts and their interactions – something that is self-organizing and can adapt (Capra, 2002; Johnson 2001). Complexity scientists describe this type of self-organizing phenomenon as a 'learning system'. As such, Davis and Simmt (2003) describe complexity science as the 'science of learning systems'.

These authors understand learning in terms of the "adaptive behaviours of phenomena that arise in the interaction of multiple agents" (Davis & Simmt, 2003, p. 137), and they suggest that complexity science is defined more in terms of its objects of study than in its modes of investigation.

In order to help understand what is meant by complexity, Weaver (1948) drew distinctions between simple, complicated and complex systems. He used billiard ball collisions, as explained by Newtonian mechanics, as an example of a simple system, i.e. a system that only involves a few interacting objects or variables, and in which the interacting parts may be characterised in detail, and the behaviour of the system can be predicted with greater precision.

However, an increase in only a few interacting parts, leads to intractable computations. Consequently, Davis and Simmt (2003) believe that this level of complication has led scientists to become 'resigned' to using analytical methods, based on probability and statistics. As such systems which might involve millions of variables or parts, such as astronomical phenomena and weather, they are considered to be complicated systems. Nevertheless, complicated systems can still be predicted, albeit not with the same level of precision. In contrast, many events and systems emerge through the interactions of agents that are themselves dynamic and adaptive, and are

therefore, not entirely predictable, since they are capable of responding in different ways to similar influences and can learn new responses (Weaver, 1948). The ability to learn new responses allows coherent and self-maintaining collectives to emerge through the co-specifying activities of individuals; collectives which can maintain themselves without intentions, plans or leaders, as the collective transcends the parts and presents possibilities that are not represented in the individuals (Davis and Simmt, 2003).

There are several necessary, but not sufficient conditions that need to be met for systems to arise and maintain themselves (Davis & Simmt, 2003). These conditions, which have been adapted from Bloom (2000), Casti (1994), Kelly (1995), and Lewin and Regine (2000), are internal diversity, redundancy, decentralised control, organised randomness and neighbour interactions.

Internal diversity reflects the different ways in which members of a community can respond and interact. Redundancy is the complement of diversity, i.e. redundancy is the 'sameness' of the individuals within a system. This 'sameness' in a learning community may be a factor of knowledge, purpose, background, etc.

Redundancy in this sense may be recognised by the participants' degree of commonality of expectation and purpose; and it is essential for triggering a transition of *me's* to a collection of *us* (Davis & Simmt, 2003). Lewin and Regine (2000, p. 28) call the area of intersection between redundancy (commonality) and internal diversity, as the "zone of creative adaptability", a notion somewhat similar to Vygotsky's (1978) 'zone of proximal development' – in that both ideas refer to immediate possibilities for co-activity, but which are limited by certain criteria.

Another condition that is necessary, but not sufficient for systems to evolve and maintain themselves, is decentralised control: a situation where power and authority are

distributable, the locus of learning is the individual, the system itself 'decides' what is and what is not acceptable, and understandings and insights are co-specified and shared. The condition of organised randomness is the delicate balance between enough organisational control to direct activities, and enough randomness to allow flexible and varied responses. Within the notion of organised randomness, Davis, Sumara and Luce-Kapler (2000) coined the term 'liberating constraints', i.e. those that are not too prescriptive (such as 'turn to page 17 and do the geometry examples numbers 1-7') or too open-ended ('write down everything you know about geometry'), but something more enabling such as: 'Tell me what you consider to be the five most important things about geometry'.

Finally, there is the necessity for agents within a complex system that can affect ideas and activities. These are termed neighbour interactions. In the sense of complexity theory and learning communities, as promoted by Davis and Simmt (2003, p. 156) these 'neighbours' are not "physical bodies or social groupings", but "ideas, hunches, queries and other manners of representation" which must "bump" against one another.

It is the interaction of concepts and understandings that makes possible a mathematics learning community.

In order to better understand the conditions required for the development of the complex mathematical learning community I wished to promote, I attempted to position my own and students' perceptions of what influences the levels of mathematics engagement, enjoyment and confidence within the complexity of a learning community.

A clearer understanding of these agents of influence would also better inform future practices and positions that aim at developing the complex learning communities

in mathematics education that nurture students' self-efficacy within a framework of core values aiming to promote excellence.

## 9. NEW SCHOLARSHIP

Action Research is a process by which educators investigate their own actions and the consequences of their actions, and through making changes to their practices, and evaluating those changes, improve the environment in which they work (McNiff, 2002). Boyer (1990) speaks of the need to develop a new scholarship of teaching, viz. a form of scholarship that focuses on teaching itself as the object of inquiry, and which aims at creative engagement with the subject matter. Schön (1995, p. 27) believes that this type of approach necessarily involves using a form of action research "with norms of its own", and which holds promise for the development of new forms of networking in the spirit of communicative action (Habermas, 1987).

McNiff (2002) believes that action research of this type is one way of addressing calls by Snow (2001) and Hiebert, Gallimore and Stigler (2002) for the development of a knowledge basis that provides ways of systematically recording the 'rich resource' of practical knowledge that teachers generate when studying their own practice.

Elliott (1991), a key figure in the development of action research, sums up the nature of action research as research with the fundamental aim of improving practice, rather than merely producing knowledge. Ebbutt (cited in Bryant, 1996, p. 114) defines action research as involving, "The systematic study of attempts to change and improve educational practice by groups of participants by means of their own practical actions and by means of their own reflection upon the effects of those actions".

Middlewood et al. (1999) state that, in the improvement of practice, there are two aspects of action research: one is to bring about change; the other is to promote reflection amongst practitioners. The concepts of the 'reflective practitioner' or of 'reflection in action' are associated with Schön (1983), who sees reflection in action as a reflective conversation with the situation. Middlewood et al. (1999) describe action research as a process that views action following evaluation or reflection as part of one cyclical process that needs to be followed by another. This involvement with the processes of education, while they are taking place, is a dynamic involvement rather than a passive observation.

McNiff (2002) describes action research as a form of practice that involves data gathering, reflection on the action as it is presented through the data, generating evidence through the data, and making claims to knowledge based on conclusions drawn from validated evidence. Action research, therefore, entails a cyclical process of change and enquiry. It fundamentally involves self-reflection and a commitment to improving one's practices; and it can lead to the development of 'new scholarship' of one's own 'living educational theory'. This opens up to scrutiny one's own claims to have made improvements in practice (McNiff, 2002).

This study is informed by these notions of 'new scholarship', and is premised on the view that teaching is about engagement in participatory learning and the development of communities of creative scholars by means of a curriculum that takes the form of constantly emergent thoughtful conversations (McNiff, 2002).

## 10. THE RATIONALE FOR THIS STUDY

Edmundson (2004) believes that we challenge our educational ends and teaching approaches by asking ourselves whether we can put our approaches into action, in order

to live and teach better – and whether these approaches are able to influence our existing educational beliefs in consequential ways that would make a difference. Woolfolk (2004) claims that teachers who set high goals and have a high sense of efficacy themselves are more likely to have students who experience success.

These beliefs have fuelled my desire to create opportunities for students to experience success and excellence, and to describe the effect of these opportunities in terms of outcomes that I have set within a framework of values and constructivist tenets. My intention, therefore, is to improve my practice by using a values-based approach to implement classroom strategies which I believe will produce the desired results of improving academic learning, as well as the confidence levels of the students in my mathematics education classes.

## 11. SUMMARY

In this chapter, I have provided an overview of the literature and theoretical framework for this research study. Various definitions of the concepts of inquiry-based learning and teaching were outlined, and the importance of this teaching and learning theory for both teachers and learners was highlighted. Current thinking on inquiry and its relevance for education nationally and internationally was discussed; and the model of inquiry used to promote excellence and self-efficacy amongst mathematics education students was interrogated.

The challenges faced by education in South Africa, particularly since the new dispensation in 1994, as well as the attempts made by government to implement a curriculum relevant in content and context, sets the scene for this study. The introduction of a National Curriculum Statement which is underpinned by an inquiry-based philosophy of teaching and learning aimed at transforming education and empowering all citizens, has

apparently had little effect on teachers' low levels of motivation and the frequent lack of appropriate implementation plans.

These considerations underpin the rationale for this study and the focus on self-efficacy. As the newly revised mathematics curriculum requires that understandings in mathematics should extend beyond the knowledge of concepts, and inquiry-based teaching and learning, this investigation of a values-based approach to teaching and learning could suggest strategies for transforming education and fostering vitality in teaching and learning.

Finally, the issue of moral values was integrated into the strategy used in this study – to gauge whether making values explicit could help promote notions of excellence in students (prospective teachers) and improve their self-efficacy in terms of mathematics. The findings were viewed through the lens of complexity theory, with a particular focus on the requirements needed to develop a complex learning community. The study took place within an approach which encompasses aspects of the 'new scholarship', and, as such, fundamentally involved self-reflection aimed at improving my practice – in order to develop my own 'living educational theory', in terms of my own mathematics teaching at tertiary level.

# CHAPTER THREE

# METHODOLOGY

## 1. INTRODUCTION

In this methodology chapter I provide an outline of the Positivist, Interpretivist, Phenomenological and Critical Theory research paradigms, and consider their roles – in order to provide a background against which I explain how this study is informed by notions of 'New Scholarship' (McNiff, 2008). New scholarship is premised on the view that teaching is about engagement in participatory learning and the development of communities of creative scholars. I explain the philosophy on which this research is based and include reasons for the particular approaches and methods that I have used.

An outline of how the effect of the values-based approach to teaching and learning has been assessed in terms of improving students' mathematics self-efficacy is also described.

The differences between qualitative and quantitative research methods, the different types of data required and the instruments and techniques used for gathering the data will all be discussed in detail. Reasons for the selection of specific instruments and techniques are explained and attention is also given to the methods of analysis of the data. I have discussed the use of affective-disposition statements, interview schedules, reflective journals and a video-recorded lesson, as appropriate strategies for gathering data which relate to a values-based approach to teaching and learning and investigate students' mathematics self-efficacy.

The sample type and size is discussed and justified, and issues of validity, reliability and ethical considerations are addressed. The methodological limitations of the study are also outlined.

This research study is an investigation into perceptions of first- and second-year mathematics education students (n=130) at the Nelson Mandela Metropolitan University (NMMU) regarding their mathematics self-efficacy, possible causes of negativity towards mathematics and the teaching thereof, and how a values-based approach to teaching which aims at promoting excellence, might influence students' levels of mathematics self-efficacy.

## 2. RESEARCH PARADIGMS

Methodological practices in research are influenced by the set of beliefs and practices that guide a particular field (Morgan, 2007). These sets of beliefs and practices, or paradigms, are defined by metaphysical considerations, including how knowledge is generated (epistemology), a patterned set of assumptions concerning reality (ontology), values (axiology) and the particular ways of knowing that reality (methodology) (Guba, 1990; Hanson, Creswell, Plano Clark & Petska, 2005).

Researchers suggest that these metaphysical beliefs represent a system of ideas which inform our reality; and that ultimately, one's mental framework influences the paradigm in which one works (Mertens, 2005). In other words, the paradigm that a particular theorist accepts and employs will determine not only their research methods, but will also dictate the research technique adopted (Mouton, 2001; Morgan, 2007).

Burrel and Morgan (1979) claim that, because of the commonality of purpose that binds the work of a group of theorists together, sociological paradigms can be

divided into four quadrants (Figure 3.1). The paradigm that researchers accept determines their methods and dictates the research technique adopted (Mouton, 2001). McFarlane (2000) emphasizes that research methodology should be grounded in the philosophical assumptions which underpin the existing research.

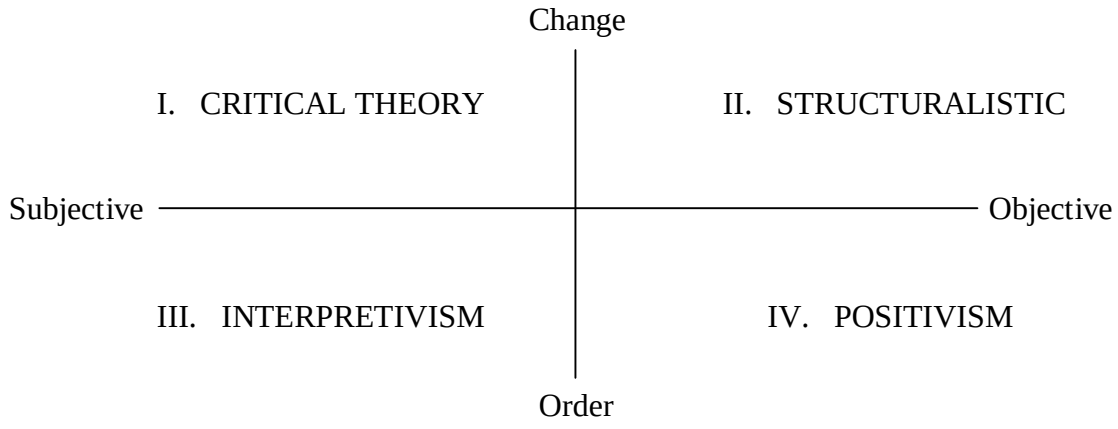


*Figure 3.1:* Research paradigms (Burrel and Morgan, 1979)

Burrell and Morgan's (1979) matrix is based on four established debates in sociology. The following description summarises how these debates inform the components of the matrix. The Critical Theory discussion deals with the notion of reality. It questions whether one's reality is developed by means of societal construction or whether that reality is what one perceives it to be. The Structuralistic argument focuses on how one begins to understand a new idea, concepts or practices, and questions whether it is necessary for one to experience something in order to understand it.

Interpretivism deals with the concept of free will. It focuses on whether individuals are guided by free will or whether their decisions are determined by their environment. The Positivism debate discusses how understanding is best achieved

through a systematic way of thinking, and through practice-based knowledge – and understanding through direct experiences.

As reflected in Figure 3.1, both positivism and interpretivism are concerned with order, but what distinguishes the two is that positivism is supposedly objective, unlike the latter which is subjective. However, many philosophers and researchers feel that the positivist approach fails to recognise that social science, unlike the natural sciences, stands in a subject-subject relation to its field of study, not a subject-object relationship (Cohen, Manion & Morrison, 2000).

Due to the nature of this empirical research of scientific inquiry, I decided that I should work within the ambit of a positivist paradigm for some aspects of this study (generating numerical data). At the same time, working within an interpretive paradigm appeared to be most appropriate for the interpretation of the data generated to address the research question: 'Can I influence my students' mathematical self-efficacy by using a values-based approach which aims at promoting excellence?'

Middlewood et al. (1999) claim that, in their experience, the practitioner-researcher is likely to make use of both qualitative and quantitative techniques, and thus adopt a stance that incorporates some elements from each of the two basic paradigms. As a teacher-educator researcher, this research study falls comfortably into this mixed-methods approach. As the main purpose of this research study is to improve my practice as a teacher-educator, some notions of action research played a role in integrating teaching and teacher development, as well as providing an opportunity for a philosophical reflection.

Although the Positivist and Interpretivist paradigms act as frameworks for this research study, they were not used exclusively. Within an educational context,

participatory research is associated with critical theory. The focus of this research study is the improvement of classroom practice; and as such, Critical Theory is also considered in the methodological practices of this research study; and notions of new scholarship infuse this study, insofar as this is an inclusive form of research which emphasises the idea of knowledge generation as a creative practice within a complex community of students.

A mixed-method approach, which includes the qualitative dimension of interpretivism and the quantitative dimension of positivism, may best describe the set of combined beliefs and practices used. In order to explain the dominant paradigms more fully, I interrogate understandings of these paradigms and give detailed descriptions of each contributing paradigm, under the respective headings that follow.

## 2.1 Positivist Paradigm

This research study makes use of instruments which provide numerical (quantitative) as well as qualitative data on aspects of the 'social reality' that participants bring to the mathematics education classes. According to Cohen et al. (2000), the 19th century French philosopher, Auguste Comte, is credited with being the first thinker to use the term positivism to describe the philosophical position in which explanation is done by means of scientific explanation.

Positivism adopts an ontology which describes the world as an entity external to the individual and his cognition. It comprises hard, tangible and relatively immutable structures (Easterby-Smith et al., 1994). This has led to the general doctrine, which states that all genuine knowledge is based on sense experience; and progress in the accumulation of knowledge can only be made by means of observation and experiment (Cohen et al., 2000).

Goodman (1992) maintains that positivism is associated with the idea that social reality (like physical reality) is controlled by laws, and that these laws control the behaviour of people who, in turn, set up social systems that reflect these laws. According to McFarlane (2000), when used in the social sciences, the positivistic paradigm seeks to emulate the natural sciences – in that it aims to find certainty, to be objective and value free. This paradigm often makes use of quantitative methods with the aim to prescribe, predict and control situations. Variables can usually be identified as the causal factors for specific types of behaviour.

It is the generation and analysis of the numerical data that place this aspect of the research within a positivistic framework, but it is the analysis and construction of understanding from these data – in terms of 'social reality' – that place the research within the interpretive paradigm and establish the need to include the new scholarship approach – in which a living theory is generated from the data findings regarding a values-based approach to teaching and learning.

Middlewood et al. (1999) claim that quantitative (suggesting positivism) and qualitative (suggesting interpretivism) data need not be mutually exclusive, but are often used together, and that in practice, research may include elements of the two apparently opposed paradigms. Johnson (1994) believes that a growing body of social research takes a stand somewhere between the two schools of thought, while recognising that no piece of social research can be completely value free.

## 2.2 Interpretive and Phenomenological Paradigms

The Interpretive Paradigm is an umbrella term for a host of different paradigms – all of which share the same objective of understanding and interpreting social situations (McFarlane, 2000). The interpretive paradigm sees the world as "constructed

rather than found" (Janse van Rensburg, 1998, p. 6); and the interpretivist researcher understands that knowledge is internally constructed (Fien & Hillcoat, 1996). They therefore see knowledge as understandable, but only through the participant's frame of reference. This study deals with judgments people make about themselves and their capabilities. Therefore, this paradigm is well suited for this interpretive theory paradigm, where the key idea is the social construction of reality and where people are seen as active agents in the creation of this reality.

Middlewood et al. (1999) advocate that it is through a variety of qualitative methods that it becomes possible to build up a picture of a social reality. The intention of using affective-disposition statements, interview processes, journal entries and reflections of a video recording of a mathematics education lesson in this research study, is to build a picture of the social reality of the mathematics education classes and participating students in these classes. In interpretive research:

> *…the task of the social scientist should not be to gather facts and measure how often certain patterns occur, but to appreciate the different constructions and meanings that people place upon their experience.*
>
> (Easterby-Smith et al., 1994, p. 78)

Interpretivism holds the view that human beings are not mechanistic, and they have multiple realities, which need to be understood in context. The social world cannot be described without investigating how people use language, symbols and meaning to construct social practice, and that no social explanation is complete unless it adequately describes the role of meaning in human actions (Le Roux, 2006).

Also, the interpretivist paradigm denies that there is an objective reality independent of the frame of reference of the observer; reality is mind-dependent and

influenced by the process of observation. It therefore, does not concern itself with the search for broadly applicable laws and rules, but rather seeks to produce descriptive analyses that emphasize deep, interpretive understandings of social phenomena (Le Roux, 2006).

The interpretivist paradigm generally leads to the use of qualitative research methods that will enable the researcher to gain a descriptive understanding of, amongst other considerations, the values, motivations and experiences of the participants in a study.

This interpretive view of knowledge resonates with constructivism, which holds the view that all knowledge, and therefore all meaningful reality as such, is contingent on human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context (Golafshani, 2003).

For the purposes of this study, phenomenology is viewed as the philosophical base for the interpretivist stance taken. The definition of phenomenology is the study of phenomena: the appearances of things, or things as they appear in our experience, or the ways in which we experience things. Thus, the meanings things have in our experience (Le Roux, 2006) are self-constructed, and important to us. Phenomenology, in the classical sense uses three approaches: describing an experience as it is found; interpreting an experience by relating it to relevant features of the context; and analysing the form of experience by being open to the world in which it exists (Le Roux, 2006).

The key element, therefore, of a phenomenological research study is that the research attempts to understand how people experience a phenomenon from the

person's own perspective. The goal of the researcher is to enter the inner world of each participant to understand his or her perspectives and experiences (Johnson & Christensen, 2004). It is for this reason that this study is informed by the notion of a 'new scholarship', which is premised on the view that teaching is about participatory learning and the development of complex communities of students.

It is my intention to attempt to enter the inner world of each student to understand their experiences and perceptions with regard to their affective disposition towards mathematics and their ability to do and teach mathematics. Once the researcher and students come to an understanding of their own perspectives and experiences, the cyclical process of change and enquiry can lead to the development of a 'new scholarship' of a 'living educational theory', and of claims to have made improvements in practice.

On the subject of phenomenological engagement, Van Manen (1990) claims that it is an appeal to each one of us on how we understand things, how we stand in life, how we understand ourselves as educators – and that human science research is a way of being and becoming. My research journey exemplifies these claims, as I interrogated my own beliefs, assumptions and practices which underpin my 'reality'. Phenomenologists see people as "active agents in the creation of reality", and that individuals interpret the world in which they live and act on these unique interpretations (Goodman, 1992, p. 119).

The key idea in phenomenology is based on the belief that reality is socially constructed. People construct meaning from their experiences. Research in this tradition seeks to understand and appreciate the different constructions and meanings people make of their experiences. According to Johnson and Christensen (2004), the

key element of a phenomenological research study is that the researcher attempts to understand how people experience a phenomenon from their own perspectives and experiences. This is what I have tried to do in this study.

The evaluation undertaken in this research study can be typified as a process evaluation, as described by Shufflebean and Shinkfield (2007).

## 2.3. Critical Theory

Habermas (1972) has argued that while both positivism and interpretivism are linked with particular social interests, it is Critical Theory that should be considered emancipatory. This implies the taking of action to change situations (Middlewood et al., 1999). As this study attempts to empower myself and my students to take charge of our thoughts and actions, and thereby to change our own situations, it may be considered to include aspects of critical theory. Henn et al. (2006) advocate that research within the critical theory paradigm, can never be entirely objective or completely value free.

Within an educational context, participatory research is associated to some degree with critical theory, as it has as its aim the improvement of classroom practice.

## 2.4 Pragmatism and the mixed-method approach

Pragmatism is generally regarded as the philosophical underpinning for mixed-method research. The paradigm is based on the notion that the research question or set of questions should guide the researcher in choosing the most suitable methodological approaches to addressing the inquiry (Tashakkori & Teddlie, 2003; Johnson & Onwuegbuzie, 2004; Creswell & Plano Clark, 2007).

Tashakkori and Teddlie (2003) suggest that the researchers within the pragmatist tradition should abide by what they term, ‘the dictatorship of the research question’,

meaning that they need to place more importance on the research question than on the method or paradigm that underlies the investigation. Additionally, they believe that a practical combination of methods may offer greater insight, or the best chance of answering specific research questions (Johnson & Onwuegbuzie, 2004).

### *2.4.1 Mixed-method approach*

Research methodologies and approaches are grounded in the philosophical assumptions that underpin existing research (McFarlane, 2000). Therefore, the objective and subjective theories of positivism and interpretivism have been conventionally distinguished, as in Burrell & Morgan's (1979) matrix, as using purely quantitative approaches and qualitative approaches, respectively (Johnson & Onwuegbuzie, 2004).

However, a growing number of mixed-method researchers suggest that research should not be restricted to exclusive paradigms and limited methodological practices (Greene, Caracelli, & Graham, 1989; Creswell, 1994; Tashakkori & Teddlie, 2006; Creswell & Plano Clark, 2007;). Rather, they state that one should choose a combination of methods that provide sufficient evidence for answering the research question, given "the inquiry objectives, research context, and the available resources" (Jang, McDougall, Pollon, Herbert & Russell, 2008, p. 222).

The mixed-method approach incorporates a distinct set of ideas and practices that separate it from the traditional qualitative-quantitative dualities. Leading mixed methodologists, such as John Creswell, Jennifer Greene, Burke Johnson, David Morgan, Anthony Onwuegbuzie, Abbas Tashakkori, Charles Teddlie, and others, offer defining characteristics of the mixed-method approach. Descombe (2008, p. 272) adequately summarises these characteristics of the approach, which involve the use of:

- Quantitative and qualitative methods within the same research project;
- A research design that clearly specifies the sequencing and priority given to the quantitative and qualitative elements of data collection and analysis;
- An explicit account of the manner in which the quantitative and qualitative aspects of the research relate to each other, with heightened emphasis on the manner in which triangulation is used; and
- Pragmatism as the philosophical underpinning for the research.

Mixed-method researchers posit that the majority of research questions generally cross paradigmatic boundaries and cannot be adequately addressed using exclusively the positivist or interpretivist philosophies. In fields such as sociological and educational research, where evaluation and achievement scores are as important as their contributing factors, mixed-method research is increasingly being used as a legitimate alternative to conventional mono-methods (Howe, 1988; Reichardt & Rallis, 1994; Teddlie & Tashakkori, 2006; Creswell & Plano Clark, 2007; Jang et al., 2008).

### *2.4.2 Rationale for using a mixed-method approach*

There are many ways in which social researchers use mixed-method research. Primarily, both qualitative and quantitative approaches or methods are employed throughout the process of collecting and analysing the data, integrating the findings and drawing inferences within a single study (Tashakkori & Cresswell, 2007). The prevailing rationales for methodological pluralism include improving the accuracy of 'mutually illuminating' data (Bryman, 2007), and producing a more holistic picture of the phenomenon under investigation (Creswell & Plano Clark, 2007; Descombe, 2008;).

Greene et al. (1989) and later Bryman (2006) identified a number of purposes for conducting mixed-method research designs. Yet, the most prominent reasons for a mixed-method design point to issues of the illustration of data, the explanation of

findings, the offsetting of weaknesses, and providing stronger inferences, as well as strengthening triangulation.

Triangulation is used to verify or support a single perspective of a particular social phenomenon (Jang et al., 2008); and it allows for greater validity through corroboration (Doyle et al., 2009). In addition, to increased validity, the use of qualitative and quantitative methods provides a clearer illustration of the data, and, as some researchers suggest, may neutralise the weaknesses in singular approaches, while building on their strengths (Creswell, 2003).

This is deemed useful when providing qualitative explanations to quantitative findings (or vice versa). For example, in this study, student interviews and journal entries were conducted with the purpose of providing both quantitative and qualitative responses, the qualitative explanations providing clarity for the quantitative findings. While triangulation is the most common and well-known design, there are three additional types of mixed-method designs. These will be discussed further in section three of this chapter.

### *2.4.3 Challenges to the mixed-method approach*

As paradigms influence 'how we know', our interpretation of reality, and our values and methodology in research, traditional methodologists posit that the combination of two distinct perspectives, such as the interpretivist and positivist paradigms, offer philosophically incompatible assumptions on human nature and the world (Howe, 1985; Lincoln & Guba, 1989).

For example, a predominant challenge in utilising a mixed-method design centres on how the researcher is able to adopt an objective position of distance and

neutrality (positivist) from the process and the participants, while promoting a subjective level of closeness and reciprocity, when attempting to understand or make sense of the participant's social realities (interpretivist) (Patton, 1990).

Challenges such as these may lead paradigmatic purists to posit that integrity of position should be maintained and knowledge claims cannot be mixed (Smith, 1983; Smith & Heshusius, 1986). Additionally, researchers are cautioned to use different research methods in such a way that the resulting combination has complementary strengths and non-overlapping weaknesses (Webb, Campbell, Schwartz, Sechrest & Grove, 1981; Brewer & Hunter, 1989; Johnstone & Turner, 2003).

## 2.5. New Scholarship

The new scholarship approach has infused this study, in that it was premised on the view that teaching is about participatory learning and I was committed to improving my practice as a teacher-educator, leading to my own 'living educational theory' and a claim to new knowledge. Since the 1940s considerable shifts have been taking place in the knowledge basis of social and educational research (McNiff et al., 2005). They further explain that these movements appeared as new forms of research that were more concerned about human experience, rather than only behaviour performance.

These more inclusive forms of research, in which qualitative descriptions are given to relate experiences in practice, concentrate on understanding the relationships among people, and between people and their environments. McNiff explains that these different traditions have been described as 'old' and 'new' paradigm research, and the 'old' and 'new' scholarship, action research being part of the new scholarship, which emphasises the idea of knowledge generation, as a creative practice that evolves through dialogue and recognises that social and environmental wellbeing can happen only when

individual people make deliberate commitments to working together to achieve their democratically negotiated goals. The 'new scholarship' paradigm is, therefore, a very suitable approach for the purposes of this study – which investigates the extent of my educational influence in using a values-based approach to teaching. This in turn, aims at promoting excellence, to encourage the development of mathematics self-efficacy in my students.

This research study is conducted with and for, not on, members of the community of mathematics education students. Bassey (1999) describes the characteristics of new scholarship research as being systematic, critical and self-critical inquiry, conducted for a clearly defined purpose, which aims to contribute to the advancement of knowledge. This research study complies with these characteristics described, and therefore could be regarded as supporting a new scholarship approach.

Lomax (1994) explains the benefits of supporting new scholarship criteria, while recognising that problems can arise within traditional academic settings. The new scholarship criteria include emphasizing the quality of the researcher's learning, as much as the situational outcomes, the process of personal professional learning, the values the researcher holds and 'lives out,' and the originality and creativity of mind and critical judgement demonstrated.

## 2.6. Paradigmatic approaches to this study

This research study is situated within the pragmatic paradigm, which holds the position that the research question, or set of questions, should guide the researcher in choosing the most suitable methodological approaches to addressing the inquiry (Tashakkori & Teddlie, 2003; Johnson & Onwuegbuzie, 2004; Creswell & Plano Clark, 2007). Within the context of the study, knowledge is generated by using empirical

evidence. It attempts to gain a deeper understanding of the social realities on which the evidence is based.

The generation and analysis of the quantitative data place this aspect of the research within a positivistic framework, yet qualitative instruments, analysis and attempts at understanding 'social reality' also place this study within the interpretive paradigm. The use of both qualitative and quantitative methods assists in providing a clearer understanding of the data (Creswell, 1994). This approach is in line with that of Hall and Howard's (2008, p. 252) viewpoint.

This viewpoint posits that "neither approach inherently overrides the other, as [value is placed on] the contributing epistemologies, theories, and methodologies, equally and all the time, despite any necessary fluctuations in the use of the quantitative or qualitative methods throughout the research process."

## 3. RESEARCH DESIGN

The nature of the investigation justified the use of both quantitative and qualitative methodologies, so as to ensure relevant, appropriate and adequate data collection. According to Johnson and Christensen (2004), the use of multiple perspectives, theories and research methods is viewed as a strength in educational research, and, as such, I have used a mixed-method approach. However, as previously mentioned, researchers are cautioned about using different research methods in such a way that the resulting combination has complementary strengths and non-overlapping weaknesses (Brewer & Hunter, 1989; Johnstone and Turner, 2003; Webb, Campbell, Schwartz, Sechrest & Grove, 1981). This approach helps to improve the quality of research because the different research methods have different strengths and different weaknesses. In the case of this study, the quantitative and qualitative research methods

are viewed as being complementary; and data sources are used to triangulate one against the other, namely affective-disposition statements, interview schedules, reflective journals and a video recording of a mathematics education lesson.

There is some agreement within current methodological researchers that multiple methods are useful in achieving a greater understanding of the events under investigation (Denzin & Lincoln, 1998). Research methods drawn from a range of paradigms, primarily of the mixed-method approach, make more in-depth understandings of events possible, and can produce different sources and kinds of information (Fraser, 1996).

Hall and Howard (2008), along with other mixed methodologists, maintain that the careful consideration of typological designs is essential when making research design decisions and working in a comprehensive structure. The first of three design considerations deals with determining the 'weight' (Creswell, 2003; Creswell & Plano Clark, 2007) and the priority of each approach used in the study (Morgan, 1998). For example, it must be decided whether the qualitative or quantitative aspects are of equal importance, or if more emphasis should be placed on one than on the other.

In the case of this research study, the qualitative aspect dominates and supports the quantitative aspect.

The next consideration involves identifying the stages in which the qualitative or quantitative approaches are to be mixed. Caracelli and Greene (1997) offer two approaches to design: component design and integrated design. In the component design, the qualitative and quantitative methods remain discrete through data collection and analysis, while the mixing takes place at the level of interpretation and inference. Conversely, the integrated design allows for incorporating and mixing methods

throughout the research process. Teddlie and Tashakkori's mixed-strands matrix (2006) expand on Caracelli and Greene's (1997) ideas to include other forms of design, such as concurrent, sequential, conversion, and fully integrated designs.

While the concurrent and fully integrated designs are consistent with Caracelli and Greene's (1997) notion of the component and integrated designs (respectively), the sequential and conversion designs offer additional practical approaches. In the sequential design, qualitative and quantitative strands are used chronologically. For example, a quantitative analysis of surveys and questionnaires may be used to formulate questions, develop instruments or form hypotheses to be tested qualitatively through interviews or focus groups.

In conversion, data are analysed accordingly, and the results are transformed for further analysis using the other methodological approach. The last considerations focus on 'the timing decision' (Creswell & Plano Clark, 2007) and 'the sequence decision' (Morse, 1991). These issues address the stages and the order in which the qualitative and quantitative methods are going to be used.

## 3.1 Typology of mixed-method research

In addition to the timing, weighting and mixing decisions of qualitative and quantitative methods, the typology of mixed-method designs is also attributed to Creswell and Plano Clark (2007). Triangulation was discussed earlier in the chapter, but the three additional designs include: 1) the embedded design, 2) the explanatory design, and 3) the exploratory design.

Caracelli and Greene (1997) first described the embedded design as having one dominant method, with the other data set playing a supportive role (Doyle et al., 2009). Within the embedded design is the embedded experimental model (quantitative

emphasis with a secondary qualitative data set) or embedded correlational model (qualitative data embedded within a qualitative design set).

Creswell (2003) describes the explanatory design, which consists of two phases: the initial phase is qualitative and the final is quantitative. Both phases are then used to explain or enhance the qualitative results. Two variants of the explanatory design include the follow-up model (specific quantitative findings which require further exploration using qualitative methods) and a participant selection model (the quantitative phase used to identify and purposefully select participants).

Finally, the exploratory design (Creswell, 2003) also uses two phases, but begins with the qualitative phase which assists in the development of the quantitative phase. This design is most often used in the Instrument Development Model (developing and testing research instruments) and in the Taxonomy Developmental Model (creating a classification system).

## 3.2 Design approaches in this study

As this study seeks to investigate how a values-based approach to teaching and learning could contribute to improving mathematics self-efficacy and promote excellence amongst mathematics education students at the Nelson Mandela Metropolitan University, both qualitative and quantitative approaches added valuable and diverse perspectives to this study. The component design described by Caracelli and Greene (1997) was used for the purposes of this research study – whereby the qualitative and quantitative methods remain discrete throughout the data collection and analytical process, and the mixing takes place at the level of interpretation and inference.

Both qualitative and quantitative methods were used in order to gain the most accurate insight into the effect of a values-based approach to teaching and learning, as well as the students' beliefs and perceptions regarding their mathematics self-efficacy. As previously described, mixed methods were embedded in the data collection and analysis of the affective-disposition statements, student interviews, reflective journal entries and the video recording of a mathematics education lesson.

The findings enhanced the researcher's insights into the participating students' classroom experiences, as well as how their perceptions of these experiences, may or may not have influenced their mathematics self-efficacy.

In studies where qualitative or quantitative methods are used exclusively, sampling procedures are often divided into two respective groups: purposive sampling and probability sampling. However, the rise of the pragmatic paradigm and mixed-method research design defies this split. Mixed-method sampling strategies combine, or suggest, intermediary points of the probability and purposive sampling positions. These methods can be used to best address the research question (Teddlie & Fen, 2007). Figure 3.2 depicts Teddlie's (2005) Purposive – Mixed – Probability Sampling Continuum.

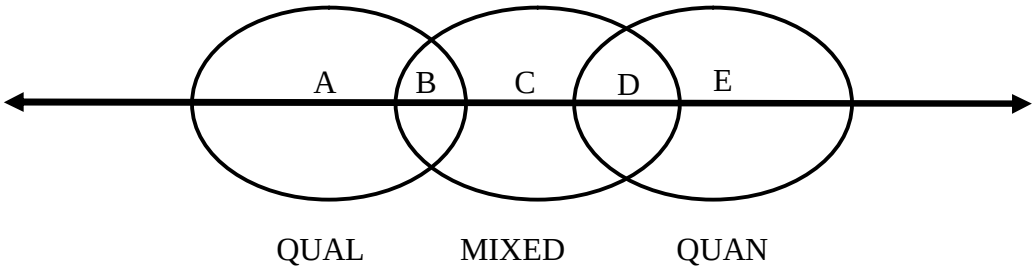


*Figure 3.2:* Purposive – Mixed – Probability Sampling Continuum (Teddlie, 2005)

Teddlie (2005) explains that the Probability Sampling continuum has various zones which represent respective sampling strategies. The opposite ends of the continuum depict separate and distinct research methods. Pure qualitative research and purposive sampling characterise Zone A, whereas total quantitative research with probable sampling characterises Zone E.

Zones B and D represent an overlap or partial integration of methods, in which priority is given to one method, but is supported by the other. In Teddlie's (2005) example, qualitative research is dominant, but it is supported by quantitative components in Zone B, while, conversely, quantitative research is prominent in Zone E, while using qualitative components to substantiate the methodology and sampling. At the centre of the continuum is Zone C - this denotes fully integrated mixed-method research and sampling.

Teddlie and Yu (2007) suggest that the combination of these orientations allows the mixed-method researcher to "generate complementary databases that include information that has both depth and breadth regarding the phenomenon under study" (p. 85). This research study falls within Teddlie's sampling continuum in that qualitative research is dominant overall, but it is supported by quantitative components. Qualitative strategies dominate and substantiate the quantitative responses given (most questions within the interview schedules, some journal entry responses where further clarification and explanation are required).

The combination of these orientations allows for the emergence of information that has both depth and breadth.

## 4. THE SAMPLE AND ITS SETTING

A sample consisting of 79 first-year and 51 second-year mathematics education students participated in this research study (n=130). All of the participants were studying towards a B Ed (Intermediate Phase) degree which focuses on the General Education and Training (GET) band of the Revised National Curriculum Statement (RNCS). The participating students were all registered for their first mathematics education module of their degree course. This is offered as a core module of the course at the NMMU in Port Elizabeth, South Africa.

One hundred and thirty students volunteered from a population of one hundred and forty-seven students registered for the mathematics education module (PICM 201).

The sampling technique used in this study included convenience and availability sampling (Grinnell & Unrau, 2005), as I approached students who were registered for my mathematics education classes at NMMU where I am a staff member. The selection of students was based on their willingness to participate in the study, and as such, they may be considered a convenience sample.

The study offered these pre-service mathematics education students - from very diverse social, cultural, economic and political backgrounds – the opportunity to reflect on their beliefs and perceptions regarding their personal and mathematics self-efficacy, with the intention of developing more positive efficacy levels. Values and notions of excellence were strongly promoted in this research study, and students were encouraged to examine their understanding and acceptance to 'live out' the agreed upon core values.

They were also encouraged to examine the meaning of the term 'excellence' and to internalise their own levels of excellence – both personally and professionally.

## 5. DATA-COLLECTION TECHNIQUES, INSTRUMENTS AND ANALYSIS

Data were collected over a six month semester period, during which the students engaged in inquiry-based experiences in mathematics education classes – in an attempt to encourage participatory learning and the development of communities of creative scholars. The intervention was underpinned by a values-based approach to teaching and learning. This aimed at promoting excellence; and students were introduced to the principles of a values-based approach to mathematics education, as well as principles and strategies of inquiry-based teaching and learning.

The data generated were analysed continuously throughout the intervention process and triangulated with one another, i.e. student responses from the affective-disposition statements, interview schedules, reflective journals and the analysis of a video representation of a mathematics education lesson that I presented. The triangulation process was an attempt to assist with the interpretation of the data generated in terms of the effect that my educational influence may have had on students' self-efficacy – via a values-based approach to teaching – with the purpose of promoting excellence in mathematics education.

The valid conclusions and appropriate recommendations which I attempted to reach, were used during the course of the study to guide my practice. According to Cohen et al. (2000), triangulation has special relevance where the issue being studied is complex, as is the case in this research study.

### 5.1 Student Affective-Disposition Statements

Pre- and post-intervention affective-disposition statements (Appendix A) provided quantitative and qualitative data which were relatively easily gathered for purposes of indicating the levels of students' perceptions of their mathematics self-

efficacy. Prior to students' engagement in the mathematics education module, they were requested to respond to an affective-disposition statement, which gave an indication of their present affective domain towards mathematics and their perceptions regarding their mathematics self-efficacy. Quantitative data were provided by respondents' individual written responses. These indicated, according to the five levels given, the degree to which they were looking forward to/not looking forward to participating in the mathematics education classes.

The qualitative data included students' explanations for their given quantitative responses, and they provided explanations for their perceived beliefs regarding their affective domains and current levels of mathematics self-efficacy. As such, the quantitative measures enabled me to understand the varying levels of self-efficacy amongst my students, both before and after their engagement in the mathematics education module, while the qualitative measures provided me with insight into their explanations for their respective self-efficacy levels.

The pre-intervention statement responses enabled me, from an informed position, to decide on appropriate classroom activities and implementation strategies which might contribute to improving the levels of self-efficacy of my students. The post-intervention statement responses indicated, according to five different levels, the degree to which students had enjoyed participating in the mathematics education course.

The qualitative responses provided explanations, and again enabled me to have a deeper understanding of students' perceptions regarding their affective domains and their levels of mathematics self-efficacy after their engagement in the mathematics education classes. These were experiences which may have led to altered levels of student self-efficacy.

Threats to the validity of this data-collection instrument were addressed by discounting any data which included incomplete or ambiguous responses to the statements. Comparisons were made with the pre- and post-intervention statement results, to consider whether the values-based approach, which aimed to promote excellence, had played any role in influencing students' self-efficacy levels.

## 5.2 Interview schedules

The semi-structured interview instruments (Appendices B and C) provided predominantly qualitative data. These were generated by probing students' perceptions and understandings on their own self-efficacy and practice. According to Mathers, Fox and Hunt (1998), if the respondent finds it difficult to answer a question or provides only a brief response, the interviewer can make use of cues or prompts to encourage the respondent to consider the questions further.

Mathers, Fox and Hunt further advocate that semi-structured interviews are useful when collecting attitudinal information on a large scale. The questions selected for the semi-structured interview underwent rigorous preparation and consideration. The same focus groups of students were interviewed pre-, mid- and post-intervention of engagement in the mathematics education course.

The intention to make audio recordings of focus group student interview responses met with some resistance from students who did not feel comfortable with the process of having their responses to the interview questions recorded. As it was important that students should feel relaxed and comfortable, and able to respond honestly to the interview questions, it was decided that the interview responses would be transcribed verbatim. Before the commencement of the interview process, each focus group of interviewees was made to feel relaxed, and the process was carefully

explained. They were told that there were no right or wrong answers, but that their responses would feed into the mathematics education course with the purpose of improving the lecturer's teaching strategies of mathematics education for intermediate-phase students in the Faculty of Education.

After scrutinizing the student interview responses, a frequency tally of student responses to interview questions was generated. The responses were then coded – using an inductive process that involved breaking up and categorizing the text to form descriptions and broad themes (Creswell, 2005) – and then grouped into broad categories. During the inductive and descriptive analysis, the steps of Tesch, as listed in Creswell (2005, p. 238) were first used independently by the interviewer, and then reviewed collaboratively by both the interviewer and the researcher – in order to reach agreement of understanding and to determine the final themes.

These steps involved, firstly, reading all the transcripts several times and making notes of the themes that emerged: grouping similar themes together and breaking up themes into main theme, categories and sub-categories; assigning codes to the themes and noting these next to the appropriate text to provide verbatim quotes; and grouping together the data belonging to each category and analysing them further.

Basit (2003) explains that the coding or categorizing of data is not synonymous with analysis, but has an important role in the analysis, and involves assigning categories. In creating categories, a conceptual scheme, suitable to the data, is constructed and then coded – using an inductive process that involves breaking up and categorizing the text to form descriptions and broad themes (Creswell, 2005).

Burns (2000) and Silverman (2000) emphasise that if two or more people have similar interpretations, then the reliability of the interpretation may be enhanced, as was the case in this research study.

Comparisons were made of analysed data from these three interview sessions to gauge the effect, if any, that the values-based approach may have had on students' mathematics self-efficacy.

## 5.3 Reflective Journals

For Bandura (1986), the capability that is most 'distinctly human' is that of self-reflection; hence, it is a prominent feature of social-cognitive theory. Through self-reflection, people make sense of their experiences, explore their own cognitions and self-beliefs, engage in self-evaluation, and alter their thinking and behaviour accordingly. Journal writing in mathematics education has been shown to be an effective tool for facilitating reflection amongst students (Mewborn, 1999), as well as an effective communication tool between students and teachers/lecturers (Burns & Silby, 2001).

Journaling has also become an accepted method for qualitative researchers to gain insights into their participants' thinking (Mewborn, 1999; Miller, 1992). In the case of this study, the use of reflective journals provided opportunities for students and my own reflections, effective communication, and gaining insights into my students' thinking.

According to Pastoll (2002), the more students express themselves, and the more constructive feedback they receive about what they are expressing, the better they will be able to shape their growing understanding of the world. All participants in this study were asked to keep a reflective journal, in which they were required to respond to

assigned formal prompts. They were also encouraged to make regular informal journal entries to maintain ongoing communication between the lecturer and themselves. These informal journal entries, made by students, included for example, expressions of their own mathematical self-efficacy and their reflections on their mathematics education experiences.

Journaling was not a familiar experience for many of the students in my mathematics education classes; and I needed to give very clear, explicit instructions of the value of journaling and the skills involved in the process of journaling; and at the same time, assure them that they would not be penalised for any grammatical or spelling errors, as the main intention of the journal was collaboration and communication. I gave each student participating in this research study an A5 exercise book, in which to record their reflective reports.

The National Council of Teachers of Mathematics advocates the use of reflection as a powerful tool to defuse potentially harmful moments in the classroom situation – by having students reflect on 'unacceptable behaviour'. For the purposes of this research study, students were given opportunities to reflect on classroom situations of 'unacceptable behaviour'. These seemed to emerge, as a result of members of the class community failing to uphold one or more of 'our' agreed upon core values. Examples of such situations are described in Chapter Five of this research study.

As such, student reflective journals provided opportunities for the collection of qualitative data regarding the influence of a values-based approach to teaching and learning. This practice may contribute to a classroom climate conducive to building a creative community of students.

Students were given five formal journal topics (prompts) to respond to in the course of the semester, in addition to using their journals as opportunities to express their queries, concerns, comments or ideas. They were assured that their opinions and comments were valued; and I promised to respond in their journals, within a two-day time frame, to every entry submitted to me. I also assured them that suggestions made in their journals for specific topics for class discussions, would be dealt with in the subsequent lecture.

The wealth of information that was gained from the student journal entries made the time it took to read and respond to them very worthwhile. Journal writing brought students' thoughts, understandings and opinions to light that would have been unlikely in typical classroom interactions, tests and tasks.

The five formal journal prompts, to which students responded during the course of the mathematics education classes, were:

- Prompt #1: Do you think the values-based approach to teaching and learning will be of some benefit in your mathematics teacher-education studies? Explain your answer.

- Prompt #2: As we come to the end of Unit 1 of PICM 201, I would like you to reflect on the lectures we have had to date. Write two paragraphs, one starting with the words: 'What I have enjoyed about the lectures so far is ...' and the second paragraph beginning with: 'What I have not enjoyed about lectures so far is ...'

- Prompt #3: In class today, we discussed the influence our thinking has had on our belief system. Read the statement below and say whether you think it is a

true or false statement. Then describe **your** own belief system regarding your ability to do and enjoy mathematics and say whether this changed at all since you started the PICM 201 course.

| |
|---|
| Without self-efficacy in mathematics (my belief in my ability to do mathematics) nothing can be achieved; but with it nothing is impossible. |

- Prompt #4: Explain whether your motivation to do and teach 'problem-solving' to intermediate-phase learners has changed at all since we discussed problem-solving strategies in class. Mention what you have enjoyed most about our problem-solving activities, and if there is any aspect of problem-solving that you would like to revise or discuss further.

- Prompt #5: Tell me what you enjoyed most about implementing your number card activity with learners. How did you feel after your first experience of 'real' teaching? Share some of your thoughts about the value of this assignment to you – both personally and professionally.

## 5.4 Video-recording of a mathematics education lesson

According to Whitehead (2009), multi-media narratives can be effectively used to 'bend the limits in language' in communicating educational influences of learning taking place in the classroom. In viewing, reviewing and analysing the video data of the mathematics education lesson, I was able to perceive aspects of my practice which influenced my own learning, the learning of students in my class, my interaction with students, and evidence of 'lived-out' values in the classroom situation.

These data seemed to communicate understandings of my educational practices – which words on a page would not have adequately communicated. As such, the data

from the video recording suggest that I was able to bring energy and a lived example of 'our' set of core values into the lecture room with my mathematics education students. According to Whitehead (2004), multimedia representations offer validity of the methodologies implemented in the classroom situation and show the lived reality of lives in action.

Eisner (2006) concurs with Whitehead and believes that the use of digital technology, especially in the production of video narratives, is extending and transforming the various forms of representation that educational researchers use.

The measuring instruments described were used in an attempt to address the primary research question in measuring educational influence on students' mathematical self-efficacy and the importance of values in education. The secondary questions which underpin the primary research question are also addressed by these instruments.

The design and development of the measuring instruments was done in such a way as to allow the data generated to reach the goal of a valid knowledge claim that I was able to influence my students' self-efficacy in mathematics education by using a values-based approach to teaching and learning. This aimed to promote the notion of excellence.

A variety of measuring instruments was used at regular intervals throughout the semester, in which the students were registered for the mathematics education module. These measuring instruments, as previously mentioned, included affective-disposition statements, interview protocols, student reflective journals and a multi-media representation of a mathematics education lesson. Specific timeframes during which these measuring instruments were implemented are described as follows:

- *Pre- and post-semester affective-disposition statements* (Appendix A) were administered at the beginning of the semester to establish students' levels of self-belief in their own abilities to do mathematics. An affective-disposition statement was again administered at the end of the semester, in order to establish whether students' belief systems regarding mathematics had altered during the semester.

- *Pre-semester student interviews* (Appendix B) which measured the students' beliefs regarding their mathematics self-efficacy.

- *Mid-semester and post-semester interviews* (Appendix C) with focus groups of students were used to regularly monitor, assess and adapt my teaching strategies – to encourage the development of students' self-efficacy with regard to mathematics-concept development and teaching.

- *A mid-semester video recording of a mathematics education lesson* (Appendix D - DVD included with this research report) was used by me to investigate to what extent the shared understanding and vision of core values was being used to influence my students' mathematics self-efficacy, and whether my intended claim to have influenced their mathematics self-efficacy was indeed a valid claim.

Data collected from the affective-disposition statements, interview schedules, reflective journals and lesson-video recording were used to build into my teaching-practice strategies and improve the way I teach and interact with students in my classes. As a result of summarizing, analysing and processing the quantitative and qualitative data, new information about students' levels of mathematical self-efficacy and their perceptions of the importance of values in education, were inevitably produced. This

new information enabled me to reflect on how my practice was continually emerging and transforming, as I engaged with my students in a pedagogical relationship, according to the principles of action research, aspects of which are used in the design of this research study.

Although there is no concrete definition for action research, teachers and teacher educators working with this method share the view that action research depends on a collaborative problem-solving relationship between the researcher and the learners/students. This aims to solve a problem and generate new knowledge.

## 6. VALIDITY AND RELIABILITY

Kvale (1989) regards the most common definition of validity as being epitomised by the question: 'Are we measuring what we think we are measuring?' According to Pervin (1989), validity generally refers to whether a method investigates what is intended to be investigated to the extent to which our observations reflect the phenomena or variables that are of interest to us.

The interview schedule used for this study complements both the affective-disposition statements and the reflective journal-response findings. In order to increase the reliability of the interview instruments, which constituted a major part of the data collection used in this study, I used an independent experienced interviewer who had previously demonstrated the ability to create a relaxed, non-threatening atmosphere.

This non-threatening atmosphere allowed students the freedom to be honest in their responses to each of the interview questions. The interviewer then analysed the data and identified some broad themes that emerged. The interviewer and researcher

then discussed the interview findings and reached agreement on the understanding and interpretation thereof – before recording these findings.

An indication of the reliability of the reflective journal responses comes from triangulation of the data. If different data sources correlate with each other, then there is a greater likelihood that the data are authentic. In this study, triangulation was made possible by the data collected from a pre- and post-intervention affective-disposition statement, pre-, mid- and post-intervention interviews, formal and informal student reflective journal entries and a video representation of a mathematics education lesson.

## 7. ETHICAL CONSIDERATIONS

Mohr (1996, cited in Halasa, 2005), claims that teacher researchers see themselves as doubly bound to ethical behaviour, both as teachers and as researchers. Further explanations assert that the degree to which a study is ethical or unethical is the result of a process of continuous interaction between the researcher and the participants. He also describes how this process must be based on an element of trust, which may be built up through the participant finding the researcher approachable; communication that is two-way; a sense that the researcher is 'human', and able to reveal personal aspects of him/herself and assurances of confidentiality. Trust, therefore, is the foundation of an ethical study (cited in Halasa, 2005).

In keeping with the accepted professional ethics of research, the aims of this study, as well as the research design and methodologies, were communicated to the participants in the programme (Mouton, 2001). As such, those who agreed to participate in the study made an informed decision to do so. Ethical measures also included the assurance of confidentiality and anonymity. All participating students were given a verbal explanation, and they also received a written letter explaining the purpose of the

research, and that their participation in this research study was voluntary, and they had the right to withdraw at any time without penalty or consequence.

Each participant signed an information and consent form volunteering his/her participation in the research study.

I believe that the procedures which I implemented enabled me to meet the standards considered appropriate for research conducted in a morally acceptable manner, as described by Creswell (2005).

## 8. LIMITATIONS OF THE STUDY

Limitations of the study are noted in respect to the research instruments used for data collection and in terms of issues related to the participants in the research study.

### 8.1 Research Instruments

The language of instruction at the university is through the medium of English. As the majority of students are either isiXhosa or Afrikaans first-language speakers, I decided to read and clarify the meaning of the affective-disposition statement – both pre- and post-intervention, before students attempted to respond in writing. I believe this practice promoted the reliability and trustworthiness of the instrument, as it accommodated participants whose home language was not English.

The same procedure was applied to the journal formal prompts and participants were encouraged to seek clarity from the lecturer, should the meaning of any of the formal prompts still be unclear to them. However, there was still a risk that the participants did not fully understand the questions or seek clarification, in spite of being invited to do so. This limitation also applied to the interview protocol, although this

was probably less of a risk, as the interviewer was able to reformulate questions and probe for more in-depth answers, as the need arose.

### 8.2 Research Participants

The student interviews were conducted in, what was intended to be, a relaxed, non-threatening atmosphere. As the affective-disposition statement responses, interview processes and formal prompt journal entries were all conducted on specific days during the mathematics education classes. Students who were absent from class on these particular days were unable to participate in the respective data-collection processes.

Numbers of participating students completing the respective data-collection processes, therefore, were not constant, but vary, according to the number of participating students attending classes on the days that the data-collecting processes were implemented. The data collected could, therefore, be biased by the diminishing number of respondents. It was the resilient, committed students who participated on a regular basis.

Nevertheless, the findings of each of the data-collection processes suggest that the data generated were valid and reliable enough to draw reasonable conclusions, and could be used to assist the ongoing transformation of my teaching strategies in mathematics education classes.

## 9. SUMMARY

This chapter, dealing with the research design, provides an overview of the research methodology used in this study. A brief review and discussion of methodological paradigms selected, as best suited to the nature of the research problem, means that this empirical study includes aspects of the positivist and interpretivist paradigms, as well as notions of ‘new scholarship’.

Motivations for this philosophical approach, which focuses on participatory learning, and the rationale for using a combination of positivist and interpretive research paradigms, are explained in this chapter, as well as how the selected research paradigms underpin the philosophy of this study.

The study uses a mixed-method approach, using both qualitative and quantitative methods for the collection of data – in order to gain deeper insight into the participants' perceptions of their own mathematical self-efficacy – and the value of using a values-based approach to mathematics education. Although more emphasis has been placed on the collection of qualitative data, both qualitative and quantitative data were gathered from the affective-disposition statements, the student-interview schedules and the reflective journal responses of the students.

Qualitative data were gathered from the analysis of the video recording of a mathematics education lecture.

The sample type and size are described and justified as adequate for meaningful analyses of data. The ethical considerations included the participants' confidentiality, anonymity and their right to withdraw from the research study at any time.

The intent of this research study was to provide a meaningful methodological model for future teachers and teacher educators, who would choose to implement a values-based approach to teaching and learning for the purposes of promoting the notion of excellence, and influencing learners and students' mathematics self-efficacy.

# CHAPTER FOUR

# RESULTS

## 1. INTRODUCTION

This chapter undertakes a systematic examination of the data generated in this study by using the methodology described in Chapter Three. The data address the research question, namely: C*an I influence my students' mathematics self-efficacy by using a values-based approach to teaching and learning, which aims at promoting excellence?*

In an attempt to answer this question all of the participating students were asked to respond to pre- and post-implementation affective-disposition statements (Appendix A). Their responses were used to investigate the students' levels of self-belief in their own ability to do mathematics. Qualitative and Quantitative data were generated from pre-, mid- and post-intervention semi-structured interviews, while the interview protocol included two closed items (which generated quantitative statistical data) and a number of standardised open-ended questions (Appendices B and C). The open-ended interview questions allowed the interviewer opportunities to use probes to gain clarity, greater depth and additional information from the interviewees.

The data generated were classified into broad themes and analysed within the framework of the literature reviewed.

Qualitative data were also generated from students' reflective journals, and from a critical reflection analysis of a video representation of a mathematics education lesson

given by the lecturer/researcher. As such, this research study made use of both qualitative and quantitative methods – where data were analysed in order to probe the knowledge, understandings and perceptions of students' belief in their ability to do mathematics.

As noted in Chapter Three, the study makes use of a variant of the mixed-method explanatory design, as described by Creswell (2003); and although the qualitative and quantitative approaches both add value and diverse perspectives, they are not of equal status in the study. The qualitative data carried more 'weight' (Creswell, 2003; Creswell & Plano Clark, 2007) than did the supporting quantitative data. The combined qualitative and quantitative results provided a more coherent picture than could be expected from either data source alone, and allowed better triangulation of perspectives, when attempting to answer the principle and subsidiary research questions posed in the study.

## 2. AFFECTIVE-DISPOSITION STATEMENTS

As noted above, the affective-disposition statements were administered both before and after the implementation of the intervention strategy. The pre-intervention statement required that all participating students respond in writing to the statement, '*I am looking forward to doing mathematics education at university this semester*'. During the post-intervention affective-disposition statement, students were requested to respond to the statement, *'I enjoyed the mathematics education module this semester'*.

For both the pre- and post-intervention statements, students were requested to first indicate, according to five given levels, the level to which they were looking forward to/enjoyed doing mathematics education at university during the first semester. Descriptions for the five given levels included, strongly agree, agree, uncertain, disagree

and strongly disagree. Their responses provided quantitative statistical data. They were then requested to give a written explanation for the respective level they had selected in response to the question.

The descriptive responses given by students to this question were organised into common broad themes to provide qualitative data. The themes for the pre-intervention statement included, 'enjoy mathematics', 'look forward to the challenge', 'desire to improve mathematical skills', 'want to become a good mathematics teacher', 'not sure if I will cope' and 'not sure what to expect', while the themes for the post-intervention statement were, 'enjoyed doing mathematics', 'improved mathematics skills', developed skills to become a good mathematics teacher', 'enjoyed the way the module was taught' and 'still dependent on assistance'.

The student sample was made up of a group of first-year students (n=79) and a group of second-year (n=51) students. All of the students in their first year of study had selected mathematics and science as core-learning areas, while the second-year students had selected languages, rather than mathematics and science, as their core-learning area. The programme design, depending on whether mathematics and science or languages were chosen as major subjects, determined whether they would be registered for their first mathematics' education module (PICM 201) in the first or second year of study.

Self-efficacy levels of the two groups of students were compared in the light of their responses to the affective-disposition statements.

Table 4.1 indicates both pre-intervention and post-intervention responses for each of the five levels described. These included strongly agree (SA), agree (A), uncertain (U), disagree (D) and strongly disagree (SD). The common themes which emerged, as previously described, are also indicated on the table on the following page.

Table 4.1:

*Emergent common themes from both the pre- and post-intervention affective-disposition statement group responses*

| Pre-Intervention | | | | | | |
|---|---|---|---|---|---|---|
| **Themes** | **Group** | **SA** | **A** | **U** | **D** | **SD** |
| Total student responses for respective levels | 1st year | 48 | 40 | 11 | 1 | 0 |
| | 2nd year | 29 | 29 | 16 | 15 | 11 |
| Enjoy mathematics | 1st year | 20 | 16 | 0 | 0 | 0 |
| | 2nd year | 12 | 8 | 0 | 0 | 0 |
| Look forward to the challenge | 1st year | 8 | 1 | 0 | 0 | 0 |
| | 2nd year | 11 | 17 | 0 | 0 | 0 |
| Desire to improve mathematics skills | 1st year | 7 | 17 | 0 | 0 | 0 |
| | 2nd year | 0 | 0 | 0 | 0 | 0 |
| Want to become a good mathematics teacher | 1st year | 13 | 6 | 0 | 0 | 0 |
| | 2nd year | 6 | 4 | 0 | 0 | 0 |
| Not sure if I will cope | 1st year | 0 | 0 | 6 | 1 | 0 |
| | 2nd year | 0 | 0 | 6 | 15 | 11 |
| Not sure what to expect | 1st year | 0 | 0 | 5 | 0 | 0 |
| | 2nd year | 0 | 0 | 10 | 0 | 0 |

| Post-Intervention | | | | | |
|---|---|---|---|---|---|
| **Themes** | **SA** | **A** | **U** | **D** | **SD** |
| Total student responses for respective levels | 51 | 49 | 0 | 0 | 0 |
| | 34 | 44 | 11 | 11 | 0 |
| Enjoyed doing mathematics | 19 | 20 | 0 | 0 | 0 |
| | 10 | 13 | 5 | 0 | 0 |
| Improved mathematics skills | 13 | 15 | 0 | 0 | 0 |
| | 10 | 13 | 0 | 0 | 0 |
| Developed skills to become a good mathematics teacher | 11 | 7 | 0 | 0 | 0 |
| | 6 | 9 | 0 | 0 | 0 |
| Enjoyed the way the module was taught | 8 | 7 | 0 | 0 | 0 |
| | 8 | 9 | 0 | 0 | 0 |
| Still dependent on assistance | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 6 | 11 | 0 |

Note: Results are given as percentages for comparison purposes

## 2.1 Pre-intervention affective-disposition statement responses

When combining the categories ‘strongly agree’ and ‘agree’, 88% of the first-year students (mathematics and science group) indicated that they were looking forward to the mathematics education course, while 11% were unsure what to expect and only 1% of this group of students indicated that they were not looking forward to the course. In comparison, when combining the categories ‘strongly agree’ and ‘agree’, 58% of second-year students (language group) indicated that they were looking forward to the mathematics education course, while 16% were unsure what to expect, and 26% of students from this group indicated that they were not looking forward to the course.

The fact that 30% more students in the first-year group than in the second-year group were looking forward to the mathematics education course was not surprising considering that the second-year group of students had specifically chosen to focus on language in their degree course, rather than on mathematics and science.

‘Fear of failure’ was the reason given by 31% of second-year students for indicating that they were not looking forward to the mathematics education course. Only 7% of first-year students indicated ‘fear of failure’ as a reason for not looking forward to the course. Statements made by students which indicated that ‘fear of failure’ was a concern for them, included, ‘I am not sure if I will cope’; ‘I get frustrated when I cannot understand a concept;’ ‘I have had negative past experiences’; ‘I struggle to understand maths’.

The results presented in Table 4.1 suggest that the group of first-year students, who had selected the mathematics and science option for their studies, entered the mathematics education classes with higher levels of mathematics’ self-efficacy than the second-year group of students who had selected the language option for their studies.

## 2.2 Post-intervention affective-disposition statement responses

When combining the categories of ‘strongly agree’ and ‘agree’, 100% of first-year students (mathematics and science group) indicated that they had enjoyed the mathematics education course. In comparison, when combining the categories ‘strongly agree’ and ‘agree’, 78% of second-year students (language group) indicated that they had enjoyed the mathematics education; course, while 11% were still unsure that they had enjoyed the course, and a further 11% did not enjoy participation in the mathematics education course.

However, it was interesting to note that in the pre-intervention affective-disposition statement responses, 26% of second-year students indicated that they were not looking forward to the mathematics education course, whereas the post-intervention statement responses indicated that 11% of second-year students did not enjoy participation in the mathematics education course. This indicated a 15% decrease in students’ negative responses towards mathematics education, and although 11% ‘strongly disagreed’ with the statement in the pre-intervention schedule, 0% ‘strongly disagreed’ in the post-intervention schedule.

These results suggest an improvement of negativity levels experienced by second-year students in the post-intervention affective-disposition results. An increase of 12% in the first-year students indicated, in the post-intervention responses, that they had a more positive attitude towards mathematics, while 20% of students in the second-year group also indicated that they were more positive towards mathematics. Although no students from the second-year group initially expressed a desire to improve their mathematics skills, 15% of students responded in the post-intervention statement that they believed that they had in fact improved their mathematics skills during the course of the mathematics education lectures.

Fear of failure was still expressed in students' responses, similar to those of the pre-intervention results, such as, 'I get frustrated when I cannot understand a concept,' 'I have had negative past experiences', 'I still struggle to understand maths'. In the pre-intervention responses 'fear of failure' was expressed by 31% of second-year students and 7% of first-year students. However, in the post-intervention responses only 17% of second-year students expressed reservations regarding their mathematics capabilities by responding that they were still fairly dependent on assistance in solving mathematics problems. No first-year student indicated that 'fear of failure' was a concern for them.

These results presented in Table 4.1 suggest that both groups of students had improved self-efficacy levels in the post-intervention results. However, the group of first-year students, who had selected the mathematics and science option for their studies, demonstrated higher mathematics' self-efficacy levels in both the pre- and post-intervention affective-disposition statement responses than the second-year group of students who had selected the language option for their studies.

## 3. STUDENT JOURNAL ENTRIES

All participating students were given five formal prompts (journal entries) at regular intervals throughout the semester lectures. Students pasted each formal prompt into their journals, made written responses, and then submitted their journals to the lecturer. The lecturer, after reading each journal entry, wrote a comment in each student's journal and returned the journals to the students within a two-day period of time. In addition to the formal prompts, students were encouraged to communicate informally with the lecturer/researcher via additional written journal entries.

The lecturer/researcher assured students that, as with the formal prompt responses, she would give a written response to each informal journal entry and return the journals to them within a two-day period of time.

The number of journals submitted varied slightly for each formal prompt, according to the number of students who were present at the respective lectures when the formal prompt handouts were given to the students.

Communications with students, during the interview process and through journal entries, suggest that they believed the journal process had facilitated a trust relationship between the lecturer/researcher and themselves. Reasons given for the development of a trust relationship related predominantly to the fact that the lecturer had responded to every journal entry within a two-day period of time, as promised, and that responses from the lecturer had been encouraging, honest and non-critical.

Some responses in this regard given by students included: *'Journals are awesome and feedback from journals shows she cares and respects us';* and *'we feel safe writing in the journals because it is confidential'*.

Each of the five formal prompts, together with a discussion of the rationale and response findings for each prompt, follows. A description of the informal journal communications between the students and the lecturer/researcher is also discussed, following each of the formal prompt descriptions.

### 3.1 First Journal Entry (Formal Prompt 1)

*'Do you think the values-based approach to teaching and learning will be of some benefit in your mathematics teacher education studies? Explain your answer.'*

This formal prompt was an attempt to support the universal move by the teaching profession to broaden and deepen the implementation of core values, as described in the literature review. The research study to introduce core values which revolve around the notion of trust and are bound by a ring of integrity had been discussed with students, as described in Chapter Two. The majority of students in the mathematics education classes, i.e. 79 first-year students and 51 second-year students, volunteered to participate in the study.

Table 4.2 below indicates the emergent dominant themes from student responses to the first formal prompt, according to the respective groups of students.

Table 4.2:

*Emergent dominant themes from student responses to formal prompt 3.1*

| **Student Responses** | **1st Year Group** | **2nd Year group** |
|---|---|---|
| Values inside the classroom inspire values outside the classroom | 47% | 33% |
| Practising values can promote positive attitudes and improve marks | 50% | 11% |
| It is important to be good role models for learners, and this gives us good guidelines | 43% | 22% |
| Promoting values is a means of maintaining discipline and mutual respect | 40% | 18% |
| Values are necessary for building responsible citizens | 18% | 15% |
| We need to learn to work together with honesty and respect | 21% | 13% |
| Values inspire a positive classroom climate | 16% | 6% |
| Values make us feel comfortable with each other | 13% | 7% |
| Values are important for building trust between the lecturer and the students – and amongst students too | 28% | 13% |

Note: Results are given as percentages for comparison purposes

The results shown in Table 4.2 above indicate consistently lower percentage scores for the second-year group of students for each of the dominant themes which emerged from their responses to the first journal entry. As mentioned previously, the second-year group of students selected a language, rather than a mathematics and science focus, for their education degree studies. The consistently lower percentage scores may suggest that their perceived low mathematics self-efficacy levels prior to attendance in the mathematics education classes negatively influenced their responses to the first given formal prompt.

Discussion regarding this takes place in Chapter Five of this research study.

Positive verbatim responses from participating students, which indicated that they were looking forward to participating in the research study included,

- *I am not usually one to question things and am looking forward to developing a spirit of inquiry.*
- *I am excited about being part of a survey that will help to change maths in the future.*
- *I am looking forward to seeing how moral values will change learners' attitude to maths in a classroom set-up.*

A challenging verbatim comment made by a participating student was, '*…everyone has different values, so you can't just teach your own values*'. The lecturer responded to this journal entry by reminding the student that, as a research study, the students had only considered and discussed the core values which pertain to fostering social cohesion, as adopted by the Faculty of Education. These values focus on the values of respect, fairness, accountability, honesty and compassion – which in turn include the notion of trust.

Another journal response from a student was, *'…this will only have a positive outcome if everyone upholds the values'*. The lecturer responded to this comment by agreeing with the student, saying that the ideal would be if every student practised the core values seriously. Unfortunately, the reality was that each person could only be accountable for their own behaviour.

The assertion of moral relativism, that there can be no shared values because everyone is an individual possessed of his or her own unique values, appears unsustained by either scholarship or by observation, as noted by Kidder (2005). The literature review in Chapter Two clearly suggests that a core of shared values, widely held across numerous cultures, appears to express itself through the five moral ideas of honesty, fairness, respect, responsibility and compassion (Fagan, 2003; Kidder, 2005; Nieuwenhuis, 2007).

### 3.2 Second Journal Entry (Formal Prompt 2)

> *As we come to the end of unit 1 of PICM 201, I would like you to reflect on the lectures we have had to date. Complete two paragraphs, one starting with the words: 'What I have enjoyed about our lectures so far is…', and the other starting with: 'What I have not enjoyed about our lectures so far is …'*

Responses to this formal prompt were organised into broad themes, which were common to three or more students. Table 4.3 indicates the broad themes that emerged and the percentage of respondents within each of the groupings of the emergent dominant themes. It was felt that there would be no benefit to recording the student responses according to respective groups (first- and second-year groups) as the themes which emerged appeared to be relevant to all participating students.

The themes are further grouped for convenience under the headings ‘influence of lecturer’, ‘student involvement’ and ‘curriculum content’. Descriptions, clarifying each of the themes will follow Table 4.3.

Table 4.3:
*Emergent dominant themes from student responses to formal prompt 3.2 within three groupings (influence of lecturer; student involvement; curriculum content)*

| **Emerging Themes** | **Positive Comments** | **Negative Comments** |
|---|---|---|
| **Influence of lecturer** | | |
| Positive attitude | 9% | |
| Enthusiastic, organised, caring, patient | 28% | |
| Pace of work too fast | | 4% |
| **Student Involvement** | | |
| Enjoy co-operative learning | 16% | |
| Appreciate that their ideas and opinions count | 33% | |
| Too nervous to ask questions | | 12% |
| Some students a distracting influence | | 18% |
| **Curriculum Content** | | |
| Clear explanations given | 20% | |
| Enjoy using different problem-solving strategies | 13% | |
| Interesting and fun | 20% | |

*Grouping 1: Influence of lecturer*

Nine percent of the responses from students indicated that the positive attitude of the lecturer enabled them to feel comfortable with participating during classes. Twenty-eight percent of the students responded that they appreciated the lecturer’s enthusiasm and passion for mathematics education, and the fact that she was organised, caring and patient, and that she made herself available for clarification and further explanations should students require this.

I took cognisance of the responses of four percent of the students who commented on their need for me to slow my pace in covering curriculum content; and I continually checked with students in this regard.

*Grouping 2: Student involvement*

Sixteen percent of the students responded that they enjoyed the co-operative learning strategies that were implemented in the lecture and felt that they had benefitted from group discussions. Students commented that they found the activities interesting and interactive, and they enjoyed feeling included and involved in the mathematics education classes. Thirty-three percent of students intimated their appreciation that their ideas and opinions were being listened to and valued.

Twelve percent of students communicated via journal entries that they did not always understand the mathematics concepts being taught, but that they were too nervous to ask questions. I gave written responses to these student journal entries and followed up with a class discussion in which I attempted to encourage student participation in class. I came to the realisation that some students find it very difficult, especially those with a low mathematics self-efficacy, to make themselves vulnerable to class ridicule by asking questions in front of the whole class.

A student journal response given to this formal prompt was, "*I am afraid to ask questions because I think that other students will laugh at me or think that I am stupid*". We discussed the topic of learners and students ridiculing others in class situations and related this to the value of respect, which was one of the core values discussed with students attending this research study. Many students related their school experiences of being victims of such ridicule; and they revealed how this had negatively affected their self-esteem.

Students agreed to practise the principle that no-one would show any form of ridicule to fellow students in our mathematics education classes. I believe that the implementation of this principle during university classes would promote easy facilitation and implementation of the principle for students in their own school classrooms.

Eighteen percent of students responded that they were perturbed by the fact that a few students were not adhering to the values code of conduct, and were a distracting influence to other students in the class. A class discussion ensued; as I wanted to be sure that our core values for the mathematics education classes reflected the views of the community of students participating in this research study. After much debate and deliberation, consensus was reached that students participating in the research study could only take responsibility for their own behaviour – and one could not enforce a values commitment onto other students.

However, all the students were expected to respect the rights of other students to quality education. Consensus was reached that if any student(s) were disrupting the mathematics education class, they would be asked to leave the lecture venue. On one occasion, subsequent to this discussion, I had to put moral courage to the test as I requested a group of disruptive students to leave the lecture venue.

Pastoll (2002) clearly advocates that being tolerant of someone does not mean that one has to put up with behaviour that is counterproductive, disrespectful, or disruptive to others. He further asserts that any teacher is entitled to set the boundaries for acceptable behaviour from students.

*Grouping 3: Curriculum content*

Twenty percent of students responded that the clear explanations given enabled them to understand the course content. Thirteen percent of students made specific reference to their enjoyment of using different strategies for solving problems, which they believe enhanced the development of their reasoning skills. Twenty percent of students also responded that they found mathematics education classes to be interesting and fun, and viewing mathematics from a teaching perspective was an exciting new experience for them.

The introduction of formal estimation activities was well received and appeared to be a new concept for the majority of students on the course. Students also mentioned that the introduction of values into mathematics education was an interesting new perspective for them, and evoked much discussion.

Six percent of students complained that the lecture venue was small and stuffy. This complaint was legitimate, and I was surprised that more students had not complained, as the students had been allocated a venue that was hopelessly inadequate for the number of students attending the mathematics education module.

### 3.3 Third Journal Entry (Formal Prompt 3)

*In class today, we discussed the influence our thinking has on our belief system. Read the statement below and say whether you think it is a true or false statement. Then describe your own belief system regarding your ability to do and enjoy mathematics and say whether this has changed at all since you started the PICM 201 course.*

*Without self-efficacy in mathematics (your belief in your ability to do mathematics) nothing can be achieved; with it nothing is impossible.*

One hundred percent of the students responded that they thought the statement given was true. Unfortunately, most students responded to this question without using the word 'I', which led to some confusion as to whether they were referring to themselves or not. An example of such a student response to indicate this was, "…that it was only through belief in one's ability to do mathematics that one could be successful".

A very small number of students (10%) responded using the pronoun 'I' with regard to their belief in their own ability to do or teach mathematics with confidence. This was disappointing, as my intention was to measure their levels of self-efficacy, in order to triangulate these findings with the results of the pre-intervention affective-disposition statement and interviews. I realise that I should have been more specific when I handed this journal prompt to the learners – by supporting it with a clear verbal explanation.

Those who failed to make a personal response made comments such as those listed below, and I was unclear as to whether they were referring to themselves or to the human population in general. These comments included:

- *Whether you think you can or you think you can't, you are right;*
- *Nothing is impossible if you believe you can do it;*
- *If you believe in yourself you can achieve your goals;*
- *Sooner or later those who win are those who think they can.*

The most common response given by students in their personal capacity, was that they have a positive attitude to mathematics which enables them to believe in their ability to achieve in the subject. Other responses of those who responded in this manner included:

- *I surround myself with positive people;*
- *I work hard to achieve at mathematics;*
- *Getting good results motivates me;*
- *I always strive for excellence.*

A student, who came to the realisation that her belief system regarding her low self-efficacy level in mathematics would not improve unless she changed her mindset, wrote the following:

- *I soon came to the realisation that I really do need to change my mindset from "I can't", to "I'll try" and "I can". I started believing in myself; and even though it is a work in progress, I'm moving forward – successfully.*

Eighty-five percent of the participants acknowledged that their belief in their ability to do mathematics had improved; and fifteen percent of the participants responded that they felt that their belief system had not changed since their engagement in the mathematics education module, PICM201. Those who believed that their self-efficacy in mathematics had not changed at all believed that their level of self-efficacy had been strong before the commencement of the PICM 201 course, and that they had maintained their positive attitude towards mathematics.

No student felt that their level of self-efficacy in mathematics had diminished during the semester. The most common response from participants, who believed that their self-efficacy in mathematics had improved, was that they were enjoying the mathematics classes and had learnt a lot. Verbatim responses to support this included:

- *I am more confident about being able to do maths;*
- *I have changed my attitude and will try to make my learners positive about mathematics.*

Reasons given by students for developing a more positive level of self-efficacy in mathematics were:

- *Things I never understood I now know;*
- *I have been influenced by the values and attitudes;*
- *I have learnt a lot because we are able to discuss our maths with others in class;*
- *The lecturer's positive attitude rubs off;*
- *The lecturer is very enthusiastic about maths;*
- *This course has enabled me to broaden my thinking, and to think out of the box;*
- *I have learnt to explain my thinking.*

### 3.4 Fourth Journal Entry (Formal Prompt 4)

*Explain whether your motivation to do and teach 'problem-solving' to intermediate-phase learners has changed at all since we discussed problem- solving strategies in class. Mention what you enjoyed most about our problem-solving activities, and if there is any aspect of problem-solving that you would like to revise or discuss further.*

The three discreet responses required from this formal prompt have been discussed separately under headings, 3.4.1; 3.4.2 and 3.4.3.

#### *3.4.1 Explain whether your motivation to do and teach 'problem-solving' to intermediate-phase learners has changed at all, since we discussed problem-solving strategies in class.*

In response to this section of the question, 75% of the students responded that they were far more motivated regarding their participation in problem-solving activities

since participating in the lectures on this topic. Twenty-one percent of the students failed to respond to this part of the question; and 4% of students felt that they had always been motivated to engage in problem-solving activities, and they were still strongly motivated, which they believed had not changed since their engagement in problem-solving discussions and activities.

No student felt that his/her level of motivation towards 'problem-solving' had diminished in any way.

*3.4.2 Mention what you enjoyed most about our problem-solving activities.*

The four dominant themes that emerged from student responses regarding what they enjoyed most about the problem-solving activities were, 'enjoyment and success experienced', 'developing effective teaching strategies', 'creating relevant problem-solving scenarios' and 'solving problems in diverse ways'. A description of each of these themes will follow in Table 4.4, in which percentages of student responses for each given theme are indicated.

Table 4.4:
*Emergent dominant themes, according to student responses to formal prompt 3.4.2*

| **Themes** | **Student responses** |
|---|---|
| Enjoyment and success experienced | 73% |
| Developing effective teaching strategies | 50% |
| Creating relevant problem-solving scenarios | 42% |
| Solving problems in diverse ways | 32% |

*Enjoyment and success experienced (73%)*

Students expressed their enjoyment and sense of achievement in successfully creating and solving problems. They enjoyed the non-threatening, collaborative problem-solving activities, and believed that their experiences of success in problem-solving activities had increased their levels of confidence and their belief in their ability to do and teach 'problem-solving' strategies to learners.

*Developing effective teaching strategies (50%)*

General comments included students' beliefs that they had developed effective teaching strategies to teach problem-solving, which would create enjoyment, interest and success for learners in their classes. Fifty percent of the students mentioned the value of Polya's problem-solving strategy, as a very helpful tool in solving problems and equipping them with effective teaching skills.

*Creating relevant problem-solving scenarios (42%)*

Forty-two percent of the students indicated that creating relevant, realistic problem scenarios for intermediate-phase learners was a meaningful activity. They enjoyed challenging each others' thinking in the creation of these problem scenarios, as well as revising and adapting their problem statements until they felt that they had developed a problem sum which would relate to the given number sentence and be meaningful to intermediate-phase learners.

*Solving problems in diverse ways (32%)*

Thirty-two percent of students, who had school experiences where credit would only be given if they solved problems using the strategy determined by their teacher, indicated their enjoyment in discovering multiple methods of solving a problem.

The high percentage of students who experienced the 'success-breeds-success' phenomenon (Spady, 1994) made me realise the importance of providing multiple opportunities for students to experience success – in order to enhance their levels of mathematics self-efficacy. Many of the students in the mathematics education classes had not taken mathematics up to matriculation level at school. Therefore, in many cases, student levels of confidence and competence in this subject were lacking.

Much time and effort was devoted to ensuring that students developed basic strategies for problem-solving activities. The importance of students' enjoyment of doing mathematics became very evident – as students engaged enthusiastically with each other in the creation of realistic, relevant problem scenarios. This activity proved to be a relaxed, non-threatening activity, as students collaborated with one another, challenged each other's thinking and developed skills for creating meaningful problems for intermediate-phase learners.

The flexibility given to students to solve problems in diverse ways was well accepted. Students were required, however, to explain their solution process to the lecturer, class or group members. The skill of verbalising their thinking appeared to be a new skill for students, and proved to be very challenging for most students who had not practised an inquiry-based methodology at school level.

### *3.4.3 Is there any aspect of problem solving that you would like to revise or discuss further?*

Four percent of students responded that they would appreciate further opportunities to practise the writing of additional relevant problem scenarios; and two percent of students requested further opportunities to write problem scenarios using fractions. The remainder of the students felt confident in their ability to write

meaningful problems for intermediate-phase learners and solve mathematical problems by using a variety of strategies.

### 3.5 Fifth Journal Entry (Formal Prompt 5)

*Tell me what you enjoyed most about implementing your number-card activity with learners. How did you feel after your first experience of 'real' teaching? Share some of your thoughts about the value of this assignment to you – both personally and professionally.*

The 'Number-Card' assignment for PICM 201 students, described below, was discussed with students two months prior to the given submission date. The reason for this was to clarify assignment requirements, and to give them sufficient time to make the required teaching-and-learning aids. Students were also expected to organise a class or group of intermediate-phase learners with whom they could implement the 'number-card' activity, reflect on their lesson, and write a four-page report, according to specific guidelines.

The assessment rubric, giving detailed criteria for the assignment, was included in each student's study guide. This assessment rubric – with the relevant assessment criteria for the assignment – was discussed at length with the students. Students agreed that they had been given clarity regarding the expectations of the assignment and that a fair time frame had been allocated for the completion of the assignment.

A limitation of this research study, which I had not anticipated, was that a small number of students appeared to have developed the sets of number cards as required, but decided not to implement the number-card activity with a group, or class of learners, as expected of them. It appeared that they had merely fabricated a report and submitted the assignment under false pretences. When assessing one of the assignments, I suspected

that the report submitted was fabricated, and I challenged the student concerned. The student admitted to fabricating his report – and was allocated a zero assessment mark. The students and I had spent a great deal of time discussing values and the role they play in education, and I was very disappointed that this particular student had disregarded our class code of respect, accountability and honesty – and had broken the thread of integrity and trust.

There is a possibility that a small number of other students in the class may have also submitted an assignment which was not valid. If so, the results may be slightly misrepresented. However, I believe that the number of students who submitted false reports is minimal, and that the vast majority of students benefited greatly from the assignment opportunity to teach a group of students, and then to write a reflective report on their teaching experience.

I realise that in future, more stringent measures will need to be put in place to ensure that dishonest behaviour does not recur.

As the formal prompt required two separate responses from students, the results of these have been recorded separately under 3.5.1 and 3.5.2 respectively.

### *3.5.1 Tell me what you enjoyed most about implementing your number-card activity with learners?*

There seemed no benefit to recording results according to separate student groups, and so results are representative of all the participating students. Three interesting dominant themes emerged from the qualitative data analysis and are represented in Table 4.5 on the next page together with the quantitative data analysis for the first sub-question of formal prompt five.

Table 4.5

*Emergent themes according to student responses to formal prompt 3.5.1*

| **Themes** | **Student responses** |
|---|---|
| Active teaching and learning strategies | 84% |
| Impact of learners responses | 43% |
| Critical self- reflection of assignment implementation | 71% |
| Confidence in teaching ability | 75% |

A discussion of each dominant theme represented in Table 4.5 follows.

*Active teaching and learning implementation strategies enjoyed by students (84%)*

Eighty-four percent of the students expressed their enjoyment of the opportunity to implement creative, active teaching and learning strategies, in which intermediate-phase learners were actively involved. According to Anthony (1996), 'active' learning denotes learning activities in which students are given considerable autonomy and control of the direction of the learning activities. He gives problem solving, small group work and experiential learning, as examples of active learning.

The number-card activity implemented by the students, therefore, falls into Anthony's description of 'active' learning activities. Llewellyn (2005) asserts that inquiry-based classrooms provide opportunities for active involvement in the learning process, where learners feel that their teacher and peers value their ideas, thoughts and opinions.

The introduction of co-operative teaching and learning strategies appeared to promote the levels of interaction and enjoyment of the student teachers and participating learners. Sixty-one percent of the students specifically mentioned how much they had

enjoyed the interaction and participation of learners while they presented the number-card activity in their respective classes. As previously mentioned, the majority of students participating in this research study had not been exposed to interactive learning experiences during their own schooling. Much attention was, therefore, given to inquiry-based teaching and learning skills prior to the students implementing their number-card activities with intermediate-phase learners at schools.

*Impact of learners' response to the number-card activity (43%)*

Forty-three percent of students made specific mention of the sense of accomplishment they had experienced when learners indicated that they understood the mathematics concepts being taught. Students responded that they were enthusiastic about implementing the number-card activity, and they had derived much enjoyment from the teaching experience. Pastoll (2002) emphasises the importance of assignments that lead to a practical result, as he believes this helps students to judge their own progress, and through a process of trial and error, to promote confidence.

In the case of the implementation of the number-card activity, it appears from student reports, that the practical teaching aspect of the assignment created profound learning opportunities for them; and they were able to assess their own teaching skills and abilities.

*Critical self-reflection of assignment implementation (71%)*

Students generally had invested a lot of time and energy into the development of their sets of number cards, and during lecture time they had also focused on the development of effective questioning skills relating to the number-card activity. Students appeared eager to implement this activity with intermediate-phase learners. Seventy-one percent of students mentioned that the opportunity to apply the knowledge

and skills they had acquired during lectures, by implementing their number-card activity with intermediate phase learners, had provided much enjoyment and had given them a sense of success regarding their teaching skills. Students' reflections of their lessons highlighted three dominant responses, as follows:

- *Asking learners pertinent questions was a difficult skill and one in which most felt they needed more practice;*
- *Learners' questions during the lesson could not be anticipated and responding to these questions could be very uncomfortable, unless they themselves fully understood the mathematical concepts required for the number-card activity;*
- *Excitement and pride in successfully implementing a lesson using teaching and learning aids which they had developed themselves.*

*Students' confidence in their teaching ability and career choice (75%)*

Seventy-five percent of the students recorded that they had grown in confidence regarding their ability to teach mathematics during their teaching experience with the number-card activity, and they were reassured that their career choice as an intermediate-phase teacher was the correct choice. Verbatim responses from students to verify the statement regarding their confidence in their teaching-career option included:

- *I am now more certain than ever that I made the right choice to become a teacher;*
- *For the first time I knew I would enjoy teaching;*
- *This assignment got rid of any doubt about me doing teaching as a career;*
- *I can't wait to be a real teacher one day;*
- *This assignment helped me realise that I am excited for my future as a teacher, and I have made the right decision in studying education;*

- *The feeling of being successful in explaining and making children understand something they didn't understand is indescribable. It made me realise that I am in the right profession.*

*3.5.2 How did you feel after your first experience of 'real' teaching?*

Ninety-one percent of the students expressed positive sentiments about their teaching experience. The positive words and descriptions given by students to describe how they felt after their teaching experience included: *excited, proud, confident, good, happy, great, pleased, feel I made a difference, know that I love teaching.*

Six percent of students recorded that they felt *'relieved'* after their teaching experience. It was difficult to determine whether this was a positive, ambivalent or negative response.

Three percent of students expressed feelings of discouragement after their teaching experience with the number-card activity. According to these students' own admission, they had not been adequately prepared for their lesson and their number cards were not of the required standard. I had suggested to students that before they finalise their sets of number cards, they allow me to check them to make sure that their selected numbers fell into the prescribed number ranges and concepts, according to the Revised National Curriculum Statement for intermediate-phase learners.

The majority of students availed themselves of this opportunity to ensure that they submitted an assignment of a high standard, and also to ensure that their number cards would be relevant and meaningful for intermediate-phase learners. I was encouraged by this action taken by the majority of students. It indicated that they had

honoured the value of accountability in their preparation and implementation of a mathematics lesson for learners.

### 3.6 Informal Student Journal Entries

In addition to the formal journal entries (formal prompts), the students participating in this research study were encouraged to make informal entries in their journals, on an ad hoc basis, to communicate with the lecturer. No specifications were given to students regarding the content of informal written entries; they were given carte blanche to communicate any comments, opinions, complaints, queries or concerns. Journals could then be placed under the lecturer's office door or submitted at the commencement of any mathematics education lecture.

Some examples of informal journal entries made by students are given below, and topics vary from expressions of excitement about some 'new' learning that had taken place to complaints about the lecturer's perceived lack of trust in them.

- *Before this I never thought about these values in such a way and that I would need to teach them to children. Learning them now, they will benefit me. I will learn to live out these values and so will the other students. If we all strive to live out these values, it will make the classroom a pleasant place to be. We will all trust in each other and become a good group of teachers!*

The above journal entry was submitted subsequent to the first formal journal entry, in which the student had commented that, '*the values-based approach will bring some values back that are much needed*'. This informal journal entry suggests that the student possibly realised how seldom values are practised in present-day classrooms, and how they could influence a classroom climate.

- *I would like to bring this to your attention that when I put my hand up, you didn't look my way. So in turn, I don't understand the work. So please can you just check whether I have put my hand up, as I sometimes do when not understanding certain methods, and need extra help.*

The lecturer responded in the student's journal by thanking the student for bringing this to her attention. She requested that the student keep her hand raised until she saw it, or called for her attention. This was a very helpful comment made by the student and the lecturer was encouraged that the student felt confident to express this concern in her journal.

The following informal journal entry was made by a student after she had failed a written mathematics test. She was given the option to write a second test, together with other students who had not achieved a 50% pass, as an expanded opportunity to achieve a 50% pass.

- *I feel embarrassed about myself today. I disappointed my lecturer who sacrificed her time to teach me. I do not know what went wrong but the thing is that I think I panicked about the maths test at varsity. I thought I knew the work, and unfortunately the fact that I am quiet in class contributed to affect the way I learn. I learn by taking part, being active in class, listening to examples and questions. Then I can master my work. I will work even harder on the rewrite, so that I can pass my PICM 201 and know my work.*

The above informal journal entry suggested that the student had reflected on his/her disappointment at not achieving a 50% pass. The lecturer was encouraged that the student had acknowledged the value of active engagement in learning activities. The

determination of the student to work harder and pass the mathematics education course was admirable, although the lecturer was concerned that by using the word 'know' the student had perhaps referred to memorization and rote-learning strategies, which the lecturer was attempting to minimise in favour of inquiry and constructivist strategies.

Most students' schooling experiences, as discussed in Chapter Two, were characterized by traditional teaching and the importance of rote learning. Inquiry-based education was, therefore, an unfamiliar phenomenon for many of the students in the mathematics education classes.

The following informal journal entry was submitted by a student within the first week of the mathematics education classes. It seems that this student expressed the essence of one of the most common contributing factors to students' low mathematics self-efficacy levels.

- *Maam, what you said on Friday really got me thinking about the kind of teacher I would like to be. For instance, I didn't have a good experience with maths; the reason being that most of the teachers who taught me maths were about the 'right answers'. I remember how much effort I'd put into my homework, but unfortunately wasn't able to get the right answers. As a result, my teacher decided to ignore me completely. And what he did has affected the way I see maths here at varsity. Sometimes I wonder, wouldn't things turn out differently if he had been more lenient or more compassionate. Couldn't he have seen that I was eager to get my sums right, or maybe I had what it takes to get them right.*

In spite of this student's acknowledgement that her teachers' lack of encouragement contributed to her low level of mathematics self-efficacy, it seems

apparent that she still believes that she '*had what it takes to get them right'*. This suggests that she may just need her own self-efficacy to be confirmed – by 'a significant adult who believed in' her, as mentioned by Pastoll (2002) in Chapter Two as the single most dominant factor in influencing achievers.

In Chapter Two, mention was also made of Bandura's (1994) belief that perseverance in the face of difficulties has a positive influence on self-efficacy, and this student indicated that if she had been acknowledged during her mathematics classes, she would have been encouraged to persevere.

The following student journal entry was given the heading '*confession'*.

- *I have a tendency of sleeping on most of the afternoon classes, but I have to say, when I get to this maths class that all ends, because of the active learning we do.*

This journal entry again emphasises the value of engaging students in learning that requires them to be active participants rather than passive recipients of knowledge, skills and values. As mentioned in Chapter Two, Taylor and Vinjevold (1999) advocate that traditional education requires little more of learners than passive obedience and to be passive recipients of knowledge. This does not really help them to construct a sense of moral self. Pastoll (2002) supports this reasoning, and advises that we discard many traditional teaching methods in favour of learning activities in which students can feel for themselves the power of intrinsic motivation that comes from the direct enjoyment of active learning.

## 4. INTERVIEWS

Qualitative semi-structured interviews (Appendices B and C) consisting predominantly of standardized open-ended questions were used in order to allow the interviewer opportunities to freely use probes to obtain response clarity, greater depth and additional information from the interviewees. Both groups of students (n=130) were interviewed pre-, mid- and post-intervention, for the purposes of deeper probing into their beliefs and perceptions of their levels of self-efficacy, and their belief in their ability to do mathematics.

As English was not the home language of the majority of interviewees, the interviewer found it necessary at times to simplify the language of the questions to clarify meaning for them as the need arose. As mentioned in Chapter Three, it was decided to use an independent, experienced interviewer to administer the interview protocols. This may have given students the freedom to respond honestly to each of the interview questions, thereby making the data findings more valid and reliable.

The data generated via interviews were classified into broad themes and analysed within the framework of the literature reviewed.

Table 4.6 below gives an indication of the sample sizes for each of the pre-, mid- and post-interview processes.

Table 4.6:
*Student sample sizes for each of the interview processes*

| | **1st year group** | **2nd year group** | **Total** |
|---|---|---|---|
| Pre-intervention | 54 | 20 | 74 |
| Mid-intervention | 30 | 15 | 45 |
| Post-intervention | 19 | 7 | 26 |

Table 4.6 indicates that the number of student interviewees varied for each interview. Focus group interviews took place during lecture time by an independent interviewer; and they were conducted with volunteers who were present on an ad hoc basis at lectures on the particular day on which the interviews were being conducted. The number of interviewees for each interview process appeared to provide a sufficient sample size for the generation of valid and reliable data – as in each case there was little evidence that new themes would emerge from using more cases.

## 4.1 Pre-, mid- and post-intervention interview results

The pre-intervention interview was conducted prior to students' attendance of mathematics education classes. The pre-intervention interview schedule consisted of two closed questions, which provided statistical quantitative data and five open-ended questions, which enabled students to reflect on their mathematics self-efficacy, their attitude towards mathematics and what values they considered important for a lecturer/teacher to practise when interacting with students/learners.

Both the mid-intervention and post-intervention interviews consisted of two closed questions and ten open-ended questions, the first seven questions being identical to the pre-intervention interview questions – and an additional five open-ended questions. These additional questions enabled students to reflect on what was happening in mathematics education classes, and to give feedback with regard to their lecturer's ability to enhance their mathematics and personal self-efficacy.

Each of the interview questions from the student interview schedule is followed by a description of the interviewee responses and a brief summary of the most pertinent responses given.

*#1 On a scale of 1-10 how do you feel when you do mathematics?*

Students were told that this question related only to their 'feelings' about mathematics, and should not be confused with their ability to do mathematics. They were asked to rate themselves on a scale of 1 to 10, with a 'one' rating indicating that they do not enjoy doing mathematics at all, and feel very uncomfortable when doing mathematics. A 'ten' rating would indicate that they enjoy doing mathematics very much, and feel very comfortable doing mathematics.

The results in Table 4.7 indicate interesting comparisons of the pre-, mid- and post-intervention interviews for each of the two groups of students participating in the research study.

Table 4.7:
*Comparison of student group responses as they rated themselves on a scale of 1 to 10, according to their 'feelings' when doing mathematics*

| Group | Interviews | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Average score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st year Mathematics and Science Group | Pre-intervention | | | | 11 | 17 | 26 | 26 | 14 | 2 | 4 | 6,4 |
| | Mid-intervention | | | | | 3 | 27 | 30 | 27 | 10 | 3 | 7,2 |
| | Post-intervention | | | | | 10 | 11 | 26 | 42 | | 11 | 7,4 |
| 2nd year Language Group | Pre-intervention | 15 | 10 | 10 | 10 | 10 | 30 | 15 | | | | 4,4 |
| | Mid-intervention | 7 | 13 | 7 | 13 | 26 | 20 | 7 | | | | 4,1 |
| | Post-intervention | | | | | 57 | 29 | 14 | | | | 5,6 |

Note: Results are given as percentages for comparison purposes.

In contrast to the first-year students (mathematics and science group), the results suggest that the second-year students (language group) have, in general, a noticeably lower mathematics self-efficacy score. Student responses from both groups indicated

that they believed that their initial mathematics self-efficacy levels were directly linked to their success and achievement at mathematics, or lack thereof, during their school years.

The average scores indicated on Table 4.7 clearly suggest that both groups of students showed an increase in self-efficacy levels from the beginning to the end of the mathematics education course. The group of first-year students, who had selected the mathematics and science option for their studies, showed a steady increase of self-efficacy levels throughout the mathematics education classes. However, it was interesting to note that the group of second-year students, who had selected the language option for their studies, indicated a decrease in their self-efficacy levels from the beginning to mid-semester – and then an increase in self-efficacy levels from mid- to end-semester.

Figure 4.1 indicates the enjoyment levels of both groups of participating students according to the pre-, mid- and post-intervention interviews.

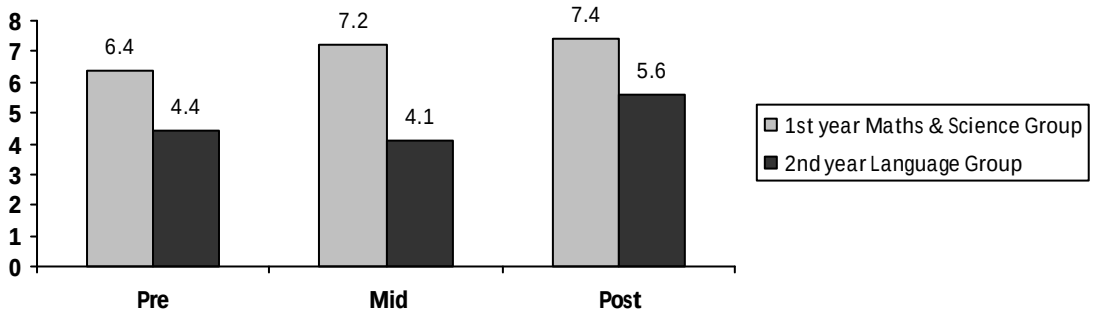


*Figure 4.1:* Pre-, mid- and post-intervention interview mean scores on a 10-point scale of levels of enjoyment when doing mathematics

Some interesting reasons were given by students regarding how they felt when doing mathematics. These will be discussed under #2 on the next page.

*#2 What do you think some reasons could be for feeling this way about mathematics?*

Student responses to this question were organised into four dominant themes, as shown in Table 4.8.below. Two themes indicated positive responses by students regarding their enjoyment of mathematics classes and the nature of the teaching they were experiencing. Two other themes that emerged were of a negative nature – describing the students' lack of confidence in mathematics and their previous experiences of unsympathetic mathematics teachers.

Table 4.8:

*Emergent dominant themes according to student group responses to question # 2 of the interview schedule*

| **Themes** | **1st Interview** | **%** | **2nd Interview** | **%** | **3rd Interview** | **%** |
|---|---|---|---|---|---|---|
| **Enjoyment of mathematics** | 1st yr group | 24 | 1st yr group | 50 | 1st yr group | 53 |
| Love of maths; enjoy challenge; fun; enjoy success | 2nd yr group | 5 | 2nd yr group | 0 | 2nd yr group | 71 |
| **Good teaching** | 1st yr group | 0 | 1st yr group | 37 | 1st yr group | 42 |
| Interesting activities, clear explanations, positive attitude, patient; helpful | 2nd yr group | 0 | 2nd yr group | 0 | 2nd yr group | 29 |
| **Lack of confidence** | 1st yr group | 50 | 1st yr group | 23 | 1st yr group | 26 |
| Struggle to understand; haven't achieved; don't feel confident | 2nd yr group | 80 | 2nd yr group | 87 | 2nd yr group | 0 |
| **Unsympathetic teachers** | 1st yr group | 28 | 1st yr group | 0 | 1st yr group | 0 |
| Lecturer/teacher didn't understand our lack of understanding | 2nd yr group | 0 | 2nd yr group | 0 | 2nd yr group | 0 |

Results are given as percentages for comparison purposes

The results given in Table 4.8 indicate that the first-year group of students, who selected the mathematics and science option rather than the language option for their

studies, showed a more positive attitude to mathematics. The pre-intervention results suggest that 24% of first-year students showed an interest in mathematics prior to their participation in their first mathematics education module at university.

The first-year students tended to attribute their achievement in mathematics, firstly, to themselves, their confidence and determination regarding mathematics, and then also to their teachers during their school years. The students' enjoyment of the subject increased from 24% prior to their participation in the mathematics education course to 53% after the completion of the course. The second-year students who selected language, rather than mathematics and science, as an elective for their B Ed degree course studies indicated a 5% enjoyment level at the pre-intervention stage. This increased to 71% after completion of the course.

It is interesting to note that no student from the language group responded with regard to any enjoyment of mathematics during the mid-intervention interview.

In response to the question of why students felt positive about mathematics, no students in the pre-intervention interview gave any credit to good teaching at school level as a possible reason. However, during the post-intervention interview, 42% of first-year students, and 29% of second-year students responded that 'good teaching' had contributed to their positive feelings about mathematics.

This indicates a general improvement in students' levels of self-efficacy after their engagement with the PICM 201mathematics education module.

During the pre-intervention interview, 50% of the first-year group of students indicated a lack of confidence in their ability to achieve at mathematics. By the post-intervention interview this figure had decreased to 26% of students, who continued to

experience a lack of confidence in their ability to succeed at mathematics. Of the second-year group of students, 80% initially indicated a lack of confidence in their ability to achieve at mathematics. This increased to 87% during the mid-intervention interview.

Surprisingly, no second-year student gave lack of confidence as a response to this question during the post-intervention interview.

During the pre-intervention interview, 28% of the first-year students responded that their school teachers did not understand '*their lack of understanding'*. As this was a pre-intervention response, students were referring to their school teachers. It was interesting to note that no second-year student gave this response, and no further such response was given by either group of students during the post-intervention interview of the research study.

*#3 On a scale of 1-10 how good do you think you are at mathematics?*

It was made clear to students before they responded to this question that they should focus only on their belief in their ability to do mathematics. This question was quite different to question one of the interview schedules, which related only to their 'feelings' about mathematics. They were again asked to rate themselves on a scale of 1 to 10, with a rating of 'one' indicating that they believed that their mathematics ability was very poor. A 'ten' rating would indicate that they believed that their ability to do mathematics was excellent.

The results in Table 4.9, which follows, indicate interesting comparisons of the pre-, mid- and post-intervention interviews for each of the groups of students participating in the research study.

Table 4.9:

*Comparison of student group responses as they rated themselves, according to their perceived mathematics ability on a scale of 1 to 10*

| Group | Interviews | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Average Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st year Mathematics and Science Group | Pre-intervention | | | | 6 | 26 | 33 | 22 | 9 | 4 | | 6,1 |
| | Mid-intervention | | | | 3 | 7 | 31 | 33 | 13 | 13 | | 6,9 |
| | Post-intervention | | | | | 11 | 11 | 26 | 37 | 15 | | 7,3 |
| 2nd year Language Group | Pre-intervention | 15 | 5 | 5 | 15 | 10 | 30 | 20 | | | | 4,7 |
| | Mid-intervention | | 20 | | 13 | 27 | 20 | 13 | 7 | | | 4,9 |
| | Post-intervention | | | | 14 | 43 | 43 | | | | | 5,3 |

Note: Results are given as percentages for comparison purposes

The data results indicate that the first-year group of students who selected mathematics and science as an elective course generally displayed higher levels of confidence in their mathematical knowledge, ability and understanding of mathematics concepts and skills than did the second-year students who had selected language, rather than mathematics and science, as a course elective.

However, the results of both groups of students show a steady increase in their mathematics self-efficacy – from the pre-intervention to post-intervention interviews. The first-year group of students showed average scores of 6,1; 6,9 and 7,3 for each of the three respective interviews, while the second-year group of students showed average scores of 4,7; 4,9 and 5,3 for their three respective interviews. Although these average scores for both groups of participating students indicate a steady increase from the pre- to post-intervention interviews, the first-year group of students indicated a decidedly higher confidence level with regard to their belief in their ability to do mathematics.

Figure 4.2 presents the average scores for both groups of participating students in terms of students' self-efficacy levels.

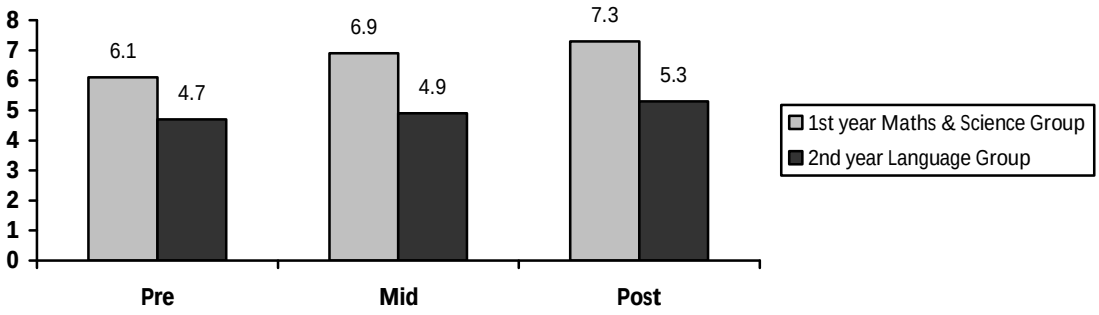


*Figure 4.2:* Pre-, mid- and post-intervention interview mean scores on a 10-point scale of mathematics self-efficacy levels

*#4 What do you like most about doing mathematics?*

The interviewer did not suggest any possible answers to this open-ended interview question, as the intention was not to influence student responses in any way. Broad themes were developed from student responses, and the table on the next page describes the two dominant themes that emerged. Under each theme, words extracted from student responses have been listed. The table indicates comparisons of student responses in percentages, according to specific student groups.

The findings suggest that students enjoyed solving relevant problems in diverse ways, and were further motivated by the success they enjoyed.

Table 4.10:

*Emergent themes, according to student group responses to question # 4 of the interview schedule.*

| Themes | Interview 1 | | Interview 2 | | Interview 3 | |
|---|---|---|---|---|---|---|
| **Experiencing success** Enjoyed finding solutions; enjoyable activities; clarity of what was expected; improved confidence and enjoyment | 1st year group | 93 | 1st year group | 90 | 1st year group | 100 |
| | 2nd year group | 80 | 2nd year group | 60 | 2nd year group | 100 |
| **Solving relevant problems in diverse ways** Relevant, practical, discovery methods, solving activities, different ways of solving problems | 1st year group | 19 | 1st year group | 40 | 1st year group | 53 |
| | 2nd year group | 20 | 2nd year group | 0 | 2nd year group | 0 |

Note: Results are given as percentages for comparison purposes

An average of 94% of first-year students (mathematics and science), and 80% of second-year students (language) across the three interviews regarded 'experiencing success' as a highly motivating factor for the enjoyment of mathematics, confirming Spady's assertion of the 'success breeds success' phenomenon. Student responses clearly indicate that one of the criteria for experiencing success was the enjoyment of achieving solutions to enjoyable activities.

Students also believed that having clarity of focus of what is expected from them was a contributing factor to the development of improved confidence and enjoyment in doing mathematics. This statement by students is supported by the RNCS (Department of Education, 2002, pp. 10-11) which guides teaching by stating that "both the process and the content of education are emphasised by spelling out the outcomes to be achieved at the end of the process".

Clarity of focus is one of the four power principles of outcomes-based education and is embedded in the National Curriculum Statement for education.

Another motivating factor which emerged for experiencing success and enjoyment in mathematics was the opportunity to solve relevant problems in diverse ways. The classroom climate adopted for the university mathematics education module supports the Revised National Curriculum Statement. This requires a transformative curriculum practice of constructivism and inquiry-based learning.

*#5 What don't you like about mathematics?*

Student responses to this question were analysed with only one theme dominating, that of the 'fear of failure'. This dominant theme fully supports the emergent dominant theme to the previous question of: 'What do you like most about doing mathematics?' One of the two dominant themes which emerged for this question was '*experiencing success*'. It appears, according to responses from questions four and five, that mathematics self-efficacy is influenced by experiences of achieving success. This finding concurs with Pajares' (2002) belief, as described in Chapter One, that students who perform well in mathematics are likely to develop a strong sense of confidence in their mathematical capabilities, whereas poor performance generally weakens students' confidence in their capability.

Pajares further advocates that highly regarded teachers who model excellence in their teaching can use their educational influence to encourage self-belief in students. I trust that my attempts at modelling excellence have had a positive impact with regard to influencing students' improved levels of self-efficacy.

The results for each group of participating students are given in Table 4.11 below. The most common phrases used by students to explain their fears relating to failure in mathematics are listed in the table.

Table 4.11:

*Comparison of respective groups of student responses giving 'fear of failure' as the dominant response to interview question # 5*

| **Categories** | **Interview 1** | | **Interview 2** | | **Interview 3** | |
|---|---|---|---|---|---|---|
| **Fear of failure** | | | | | | |
| Not understanding, fear of getting answers wrong, frustration of not being good at maths | 1st year | 76 | 1st year | 41 | 1styear | 47 |
| | 2nd year | 95 | 2nd year | 73 | 2nd year | 57 |

Results are given as percentages for comparison purposes

The pre-intervention results indicate that 76% of first-year students and 95% of second-year students experienced the emotion of 'fear of failure' with regard to mathematics education. Throughout the interview process, the second-year student responses indicated a more severe level of 'fear of failure' than those of the first-year student responses. This concurs with the findings of the affective disposition statement which was administered prior to students' engagement with the mathematics education course.

Thirty-one percent of second-year students and seven percent of first-year students cited 'fear of failure' as the most common reason for 'not looking forward to' their mathematics education course.

It was interesting to note that although 47% of first-year students and 57% of second-year students indicated in the post-intervention interview that fear of failure was still a negative factor in the development of their mathematics self-efficacy, the intensity levels of their fear of failure had dissipated, and most students were able to specify and clarify their fears. Comments made by students during the third interview process

included responses such as: *I still get frustrated when I don't get the answers correct; I still don't like the theory sections,* and *I still find it difficult to verbalise my maths reasoning*.

These comments indicated that students are able to identify and acknowledge their areas of concern in mathematics more easily.

*#6 What do you do when you don't understand something in mathematics?*

This open-ended interview question did not suggest any possible answers and students were asked to reflect on their past experiences when answering the question posed. Again, the student responses were organised into broad themes according to the most frequent responses given to the interview question. The dominant themes that emerged were: '*Work it out alone'; 'ask a friend'; 'ask the teacher'; and 'give up'*.

It was interesting to note that the group of first-year students, who had selected the mathematics and science focus in their studies, indicated lower levels of confidence in their responses regarding 'working it out alone' than did the second-year students who had selected language as a focus in their studies. Across all three interview processes an average of 26% of first-year students responded that they were confident enough to 'work it out alone' compared with an average of 30% of second-year students.

However, the first-year students showed an increase of 8% in their confidence levels of 'working it out alone', according to responses from the first to the third interview. The second-year group of students indicated a decrease of 16% in their levels of confidence, according to their responses from the first to the third interview.

Students, who responded that they were more comfortable to ask a friend to help them before they would ask the teacher, gave one of two reasons for their response. The dominant reason was that friends would be able to explain to them 'on their level', and they could then solve the problem together. The second reason was that they were too nervous to ask the teacher. Most students, who responded that they would rather ask the teacher to assist them, supported their response by saying that they had more confidence in the teacher's ability to explain things clearly and correctly to them.

It was interesting to note that in the pre-intervention interview no second-year student responded that they would 'give up' if they did not understand the mathematics. However, during the mid- and post-intervention interviews 27% and 29% respectively admitted that they would get frustrated and 'give up' if they were unable to solve the problem.

*#7 What values do you think are important for a lecturer to exhibit when teaching mathematics? Explain your answer.*

In the pre-intervention interview responses from students regarding values of patience, friendliness and respect were dominant. These values have been categorised under the broad theme of patience, as shown in Table 4.12 on the next page. The second round of interviews was conducted mid-semester, while the intervention strategy was being implemented.

Three broad themes emerged from the student responses during these interviews and they focused predominantly on patience, teaching ethics and skills, passion and enjoyment of the subject. Words and phrases mentioned by students in response to this question are listed below each broad theme. A comparison of the data, given in

percentages, clearly displays how the responses changed as students engaged with the mathematics education content.

Table 4.12:

*Emergent dominant themes from student responses to question #7 of the interview schedule*

| Categories | Interview 1 | | Interview 2 | | Interview 3 | |
|---|---|---|---|---|---|---|
| **Patience** | 1st year | 100 | 1st year | 57 | 1st year | 53 |
| approachable; friendliness; encouraging; understanding; respect | 2nd year | 100 | 2nd year | 80 | 2nd year | 100 |
| **Teaching ethics and skills**: | 1st year | 35 | 1st year | 63 | 1st year | 68 |
| Understanding of subject; thoroughness; preparedness; accountability; organised; ability to simplify; respect for learners and learning styles; fairness | 2nd year | 90 | 2nd year | 93 | 2nd year | 80 |
| **Passion and enjoyment of the subject:** | 1st year | 67 | 1st year | 53 | 1st year | 79 |
| Confidence in students, passion for maths, passion for teaching, enthusiasm and creativity in teaching; practical, interesting activities; enjoyment and excitement; positive attitude. | 2nd year | 30 | 2nd year | 53 | 2nd year | 20 |

Note: Results are given as percentages for comparison purposes

It was interesting to note that first-year student responses indicated a progressive decline in regarding patience as a priority value, while second-year student responses indicated that they continued to regard patience as an important value in the teaching of mathematics. This may suggest that the lower the mathematics self-efficacy of the student the more important it would be for them to experience patience from the teacher or lecturer – to encourage improvement of their mathematics self-efficacy levels.

Questions 8 to 12 were not part of the pre-intervention interview process, and were only applicable to the mid- and post-intervention interviews. Results of responses

for these questions are, therefore, only applicable to the second and third interviews. The mid- and post-intervention interviews, as previously mentioned, consisted of two closed items and ten open-ended questions, the first seven questions being the same as the pre-intervention interview questions; and an additional five open-ended questions which follow enabled students to reflect on their mathematics education classes and give feedback with regard to their lecturer's ability to enhance their mathematics and personal self-efficacy.

*#8 Do you think that your lecturer is living any of the core values in her mathematics education classes? If so explain how.*

Students were reminded of the five core values of respect, fairness, accountability, honesty and compassion which were being focused on in the mathematics education classes. They were asked to identify which values, if any, the lecturer was 'living out' – and provide explanations of the manner in which it was evident to them.

Below is a description of student responses for each of the five core values which the lecturer had committed to living out during her mathematics education classes.

*The Value of Respect*

For the second and third interviews 98% of the students participating in this research study believed that the lecturer was living out the value of respect in her engagement with students. The most frequent explanations given by students as indicators of the lecturer living the value of respect, which were common to both the second and third interviews, are listed below.

- *There is mutual respect between the lecturer and the students;*

- *Students feel respected even if they struggle with mathematics;*
- *The lecturer listens to the students and she expects students to listen to each other;*
- *Students feel that the lecturer treats everyone fairly, and doesn't compare students;*
- *Journal responses written by the lecturer show that she respects us.*

One of the student responses, however, indicated that he/she felt that the lecturer had treated her with disrespect. During a written test the student was sitting particularly closely to a fellow student. The lecturer asked the student concerned to move her chair further away from the fellow student. The student who had been asked to move felt that the lecturer had been disrespectful, and had indicated that she did not trust the student concerned. The lecturer explained to the student that test and examination procedures expected that students sat in a position where they were unable to read another student's work.

The lecturer further explained that it was not fair for any lecturer to put students in a compromising position where they were able to see other students' test work. The reason that students were sitting particularly closely to each other was that the venue allocated for the mathematics education classes was inadequate for the large number of students registered for the course.

A few students commented that they believed some students were disruptive in class, and that they did not always show respect for the lecturer or fellow students. The reasons given for this also referred to the large numbers of students in the class.

*The Value of Fairness*

An average of 94% of all participating students felt that the lecturer displayed fairness in her dealings with the students. The students (6%) who indicated that they believed there was a lack of fairness on the part of the lecturer, felt it was unfair that they were not permitted to make formal class presentations using their home language of Afrikaans. The lecturer explained that the university language policy states that English is the official medium of instruction. There were a number of Xhosa-speaking students in the class who have no or little understanding of the Afrikaans language, who would have been unable to understand or participate in any presentations delivered in Afrikaans.

This comment was therefore discussed with the students to clarify any misconceptions there may have been.

The most common responses given by students in the mid- and post-intervention interviews, which they believed were indicators of the lecturer living out the value of fairness, were organised into broad themes. Two dominant themes, namely, '*discipline and classroom climate'* and *'teaching ethics and strategies'* emerged from the students' responses. These responses are given below as indicators of the emergent themes:

- Discipline and classroom climate
  - *Students believed that the lecturer set fair boundaries regarding class discipline and that she was willing to discuss these boundaries. She dealt with disruptions in class with fairness, and she addressed the individuals who caused disruption;*
  - *Students believed that the lecturer's assessment of their tests, tasks and assignments was fair;*

- *Students commented that they were given opportunities to voice their opinions and the lecturer showed no favouritism towards certain students.*

- Teaching ethics and strategies
  - *Students appreciated that multiple-teaching strategies were used to help them understand the work;*
  - *If students achieved less than 50% in a test, they were permitted to rewrite the test in a second attempt to obtain 50%, which was regarded as a 'pass';*
  - *Students felt that the lecturer understood students' perspectives and acknowledged their own methods of calculation;*
  - *Students believe that they had clarity regarding what was expected of them in class and in assessment tasks;*
  - *The marks allocated for tests, tasks and assignments matched the effort required by student.*

*The Value of Accountability*

One hundred percent of students in both the second and third interviews responded that they believed that the lecturer lived out the value of accountability in her engagement with the mathematics education lectures and the students. The student responses for both the second and third interviews were analysed and the common dominant theme that emerged was '*lecturer ethics* and *teaching strategies*'.

In terms of lecturer ethics and teaching strategies:

- *Students agreed that the lecturer was punctual, organised and well-prepared for classes;*
- *They experienced the lecturer to be firm but very approachable;*
- *Marked tests were always promptly returned. The lecturer made a pact with students at the beginning of the mathematics education course that*

*any test they wrote, or task given, would be marked and returned to them by the next lecture, which in most cases was a two-day turn around timeframe. Pastoll (2002) advocates that the sooner a learner obtains feedback, the quicker she can gain control of her learning. He explains that teachers who keep their students in a state of anxiety for weeks after a test has been handed in, are quite simply preventing students from gaining control, and diminishing their chances of developing confidence in relation to that part of the work;*

- *Students appreciated the fact that tests covered the work completed, explanations regarding test scripts was done during the lecture when their tests were returned to them, and they were permitted to check their marks and ask questions to clarify any misunderstandings;*
- *The students believed that they were all given equal opportunities and the lecturer made herself available for assistance outside of class time;*
- *Students experienced the lecturer to be reliable and she practised what she preached regarding living out the five core values.*

*The Value of Honesty*

All participating students agreed that the lecturer lived out the value of honesty in her relationships with the students and they could relate experiences of this to the interviewer. Responses given by students in the second and third interviews were analysed and themes which were common to both interviews were recorded. Two dominant themes emerged, namely, '*discipline and class atmosphere*' and '*teaching ethics and strategies*'. Verbatim responses from students, which they believed were indicators of the lecturer living out the value of honesty, are given:

Discipline and class atmosphere

- *We know the lecturer's values through the way she behaves towards us;*
- *The lecturer is true to her word;*
- *Lecturer will admit if she has made a mistake. She will apologize and give an explanation if necessary.*

Teaching ethics and strategies

- *Feedback from the lecturer is always honest and open – we appreciate that. We feel that we understand where we stand with the lecturer;*
- *The lecturer does not impose her will on us and is willing to meet us half way;*
- *She gives honest responses to our journal entries;*
- *The lecturer is sincere in wanting us to achieve, so she clarifies outcomes of tests, assignments and tasks.*

A discussion about students' belief that their lecturer was living out the value of compassion in her interaction with them is described under the following heading.

*The Value of Compassion*

There was initial confusion amongst many of the students regarding the meaning of the word 'compassion'. They confused 'compassion' with the term 'passion'. The interviewer clarified the meaning with students who had responded with incorrect understandings of the meaning of compassion.

Ninety-five percent of the student responses indicated that they believed that the lecturer displayed the value of compassion, when relating to students in the mathematics education classes. Five percent of students responded that there had been times when they felt that the lecturer was not in a position to display the deep levels of compassion which related to their personal experiences. These students expressed that, although the

lecturer had attempted to encourage students who had negative attitudes to mathematics, they believed that her personal experiences were in many ways very different from theirs, and they did not believe that she would be able to understand the circumstances which had led to the development of their negative attitudes. One student responded that, with the large number of students in the mathematics education classes, their awareness of the lecturer's compassion had been somewhat hampered.

The responses of students for the second and third interviews were again analysed and organised according to common themes relating to both interviews. Two broad themes, namely, '*discipline and class atmosphere'* and '*teaching ethics and strategies'* emerged. These were the same themes that emerged for the value of honesty. Student verbatim responses are given below as indicators of respective emergent themes.

Discipline and class atmosphere

- *The lecturer's teaching practice indicates that she cares about the students and is sensitive to our needs;*
- *The lecturer is passionate about teaching;*
- *We value journal feedback from the lecturer as she understands us and takes our feelings into account when responding;*
- *The lecturer believes the best of her students and wants us to achieve.*

Teaching ethics and strategies

- *The lecturer is always prepared to help during class and out of lecture time;*
- *We appreciate that when we express confusion with maths concepts in our journal entries the lecturer will give explanations during the next maths lecture;*

- *The lecturer uses multiple-teaching strategies;*
- *The lecturer goes from group to group asking students individually if they understand the maths concepts being discussed;*
- *The lecturer sends e-mails to students to keep us informed of important matters.*

Table 4.13 below gives an indication of the quantitative statistical data relating to question eight of the interview schedule. This required students to identify which of the five core values they believed that the lecturer was living out in the mathematics education classes.

Table 4.13:
*Comparison of quantitative student responses with regard to values 'lived out' by the lecturer in the mathematics education classes*

| **Value** | **Group** | **2nd interview** | **3rd interview** | **Average %** |
|---|---|---|---|---|
| Respect | 1st year group | 100 | 100 | 100 |
| | 2nd year group | 93 | 100 | 98 |
| Fairness | 1st year group | 83 | 100 | 94 |
| | 2nd year group | 100 | 100 | 100 |
| Accountability | 1st year group | 100 | 100 | 100 |
| | 2nd year group | 100 | 100 | 100 |
| Honesty | 1st year group | 100 | 100 | 100 |
| | 2nd year group | 100 | 100 | 100 |
| Compassion | 1st year group | 90 | 100 | 95 |
| | 2nd year group | 100 | 100 | 100 |

Note: Results are given as percentages for comparison purposes

*#9 Have you any comments about the idea of including a focus on values when teaching mathematics?*

Two of the participating students (0,04%) in the mathematics education classes felt that a focus of values in mathematics teaching was not important, as it took up a lot

of time. They also believed that teaching values at university level was too late to make a difference to students. Three students (0,05%) agreed that values had a role to play in education, but felt that at times there was too much focus on values. The majority of participating students (99,1%) regarded values as making a positive contribution to their engagement in mathematics education.

Responses received from students, regarding the importance of including a focus on values when teaching mathematics, were organised into broad themes which emerged. These themes related to the *use of journals; the impact of values in mathematics education classes; the ripple effect on the broader community* and the question: *'Do values have a place in mathematics education classes?'* The four themes that emerged are discussed below.

*Use of journals*

Student responses indicated that the use of journals in their mathematics education classes was a motivating factor in the reflection and internalisation of values, and the role they play in contributing to social responsibility and social cohesion amongst the community of students. Students appreciated the time the lecturer spent in responding to each of their journal entries and believed that the written communication with the lecturer had enabled them to feel that the lecturer had a personal interest in them, despite the anonymity of the journal entries.

*The impact of values in mathematics education classes*

Students indicated that they felt it was very important that their lecturer should model the core values, and they also recognised the role that values play in developing a climate of respect and trust in a classroom situation. This, in turn, fosters an

environment which is conducive to optimal learning. They further believed that "doing well comes naturally if you exercise the right values".

Students appreciated that they felt 'listened to' and that their ideas counted. They appreciated that the lecturer displayed notions of excellence in her work and modelled her "love" of her work and respect for students. Students indicated that the use of values had made them feel better about themselves, and they perceived the work to be easier because of the respect and sensitivity shown during these mathematics classes. However, there was still a strong sense amongst students that values could only be effective if they were reciprocated.

*Ripple effect on the broader society*

Students appreciated the opportunity to practise values in their mathematics education classes and believed that values enrich and "make better people". They further believed that the implementation of a values-based approach to teaching and learning promotes more positive attitudes, improves performance and creates opportunities for the development of a positive relationship with the lecturer. They acknowledged the importance of values for the wider community and society at large.

*Does a focus on values really have a place in mathematics education classes?*

Many students acknowledged that they were "initially not sure", and had "never thought of it like that", but now believed that "every teacher should have them, not only have them, but live them". Two percent of students believed that "intellect and emotions are separate disciplines", and that values do not have a meaningful place in mathematics education classes.

They, however, acknowledged that respect was important, but thought that it was too late to introduce such values at university level. They firmly believed that we

should “stick to maths” in mathematics education classes and that “manners should be taught at home or in other classes”.

*#10 Has your lecturer helped you in any way to develop a sense of trust in her? Explain your answer.*

The verbatim responses by students to this question indicate that the lecturer had succeeded in inspiring a sense of *trustworthiness* in the students. This is defined by Kidder (2005) as the manner in which an individual acts so as to engender trust and merit the confidence of others. *Trustfulness,* he explains is the value ‘whereby an individual expresses a sense of confidence in others’.

As a lecturer-researcher I attempted to display trustworthiness by inspiring my students to feel confident in and rely on me. In order to create trustworthiness (engender trust and merit the confidence of others), I endeavoured to act with trustfulness (express a sense of confidence in others). I did this by first extending a sense of trust to others so that they would trust me (Kidder, 2005). Trust is defined by the Oxford English Dictionary as, ‘confidence in or reliance on some quality or attribute of a person or thing, or the truth of a statement’.

Trust, according to Kidder (2005), is an emotional strength that begins with the feeling of self-worth and purpose that we’re called on to extend outward to others, like the radius of a circle. He further describes the warm, solid gut feeling one gets from trust – from counting on yourself, and in trusting and being trusted by others, as one of the great enablers of life.

One hundred percent of students interviewed felt that they had developed a sense of trust in their lecturer. A contributing factor to the development of our trust

relationship, according to student responses, was the use of journals and the responses they had received from the lecturer.

Responses received from students were analysed and organised into broad themes. The emergent dominant themes for this question related to the 'lecturer's personal commitment', the 'lecturer's teaching commitment' and the 'use of journals'.

*Lecturer personal commitment*

The following verbatim responses from students indicated that the lecturer's personal commitment to her students had contributed towards the student-lecturer trust relationship:

- *Available and helpful at all times;*
- *Would not embarrass or humiliate us;*
- *Punctual and well-prepared;*
- *She interacts with us respectfully as individuals, and has a positive attitude;*
- *Positive classroom vibe;*
- *She really cares about the students;*
- *She is trustworthy;*
- *She knows our names;*
- *She goes the extra mile.*

*Lecturer's teaching commitment*

The following verbatim student responses indicate their belief that the lecturer's teaching commitment instilled in them a trust relationship with her:

- *Thoroughness of teaching;*
- *She goes out of her way to explain until you get it;*
- *Prepared to show other methods – not just one method;*

- *She doesn't test what she hasn't taught;*
- *Enthusiastic and positive.*

*Use of journal*

Students believed that the use of journals in their mathematics education course fostered a trust relationship with their lecturer. Student verbatim responses to indicate this belief included:

- *Positive feedback from journal entries often leading to class discussion;*
- *Very professional way of discussing issues in class and responding to journal entries;*
- *Journals are awesome and have helped to build trust;*
- *Journal responses show that she takes an interest in students and respects their confidentiality;*
- *The journals – safe, confidential, respect in responses.*

*#11 Do you think that your lecturer has exhibited a notion of excellence in her teaching? Explain your answer.*

As mentioned in Chapter Two, Woolfolk (2004) claims that teachers who set high goals, who persist, who try another strategy when one approach is found wanting, are more likely to have students who experience success and learn that effort pays off. It appears that students recognised these characteristics in my teaching; and in both the second and third interviews, 100% of students affirmed that the notion of excellence, as explained in Chapter Two, had been exhibited.

Student responses generally indicated that they were initially motivated to achieve in mathematics education by the extrinsic motivation provided. As their motivation levels grew, intrinsic motivation appeared to play a role in students' growing

confidence in their ability to do mathematics, as well as in their development of positive attitudes towards mathematics. The emergent dominant themes, together with the most frequent responses, given by students in their acknowledgement of the lecturer exhibiting notions of excellence in her teaching, are given below.

Table 4.14:

*Emergent dominant themes resulting from student responses given in acknowledgement of the lecturer exhibiting notions of excellence in her teaching*

| **Themes** | **Student responses which describe relevant themes** |
|---|---|
| Patience | Without patience there can be no excellence; approachable and open for questions; sympathetic when we don't understand |
| Teaching ethics and skills | Believes in us; wants us to succeed; developed a love of maths in us; motivates us to achieve more; sets the best example for us to copy; keeps us involved; feels like she is teaching individually, because she walks around to each group and asks whether each one has understood; organised; you know that she knows what's going on; mastered subject; sets high standards |
| Passion and enjoyment of the subject | Passionate about what she does and wants us to be passionate mathematics teachers; motivated by her passion; present and enthusiastic; looks forward to each lecture; made it her mission to make us good teachers; enjoys her subject; believes in her ability to do and teach mathematics |

*# 12 Do you feel that you have an increased confidence in your ability to do mathematics since the start of module PICM 201? Explain your answer.*

All first-year mathematics and science students believed that they had an increased confidence in their ability to do mathematics, since the start of the mathematics education module. In the second interview, 53% of second-year language students felt that they had an increased confidence in their ability to do mathematics. In the third interview, 100% of these students acknowledged an increased confidence in their ability to do mathematics.

However, one student mentioned that although they felt more confident in their mathematical ability, they felt less confident in their ability to teach mathematics to intermediate-phase learners. One student felt that she had confidence in her mathematical ability prior to the commencement of the course, and she believed that she had maintained this confidence.

## 5. ANALYSIS OF MY OWN LESSON

According to Whitehead (2004), multimedia representations offer validity of the methodologies implemented in the classroom situation and show the lived reality of lives in action. Eisner (2006) concurs with Whitehead and believes that the use of digital technology, especially in the production of video narratives, extends and transforms the forms of representation that educational researchers use. These show, much better than do words on a page, how to communicate the dynamic nature of living values (McNiff, 2008) in a classroom setting.

As explained in Chapter One, this study was informed by notions of 'new scholarship', and was premised on the view that teaching is about engagement in participatory learning and the development of communities of creative scholars by means of a curriculum that takes the form of constantly emergent thoughtful conversations (McNiff, 2002).

The intention was, through inspection of a video representation of one of my mathematics education lessons, to investigate whether I could possibly claim to have influenced my students' self-efficacy through a shared understanding and vision of values which pertain to, amongst others, issues of excellence.

The media department at the university made a video recording of my lesson on problem-solving. After critically viewing this lesson several times, the data were analysed – and then organised into broad themes, according to the core values of respect, fairness, accountability, honesty and compassion being considered in this research study, and whether these values were being lived out in the classroom situation. The lesson was also analysed as to whether the lecturer had succeeded in using these values to influence the students' mathematics self-efficacy.

The descriptions below give a clear indication of the findings of the analysis of the video recording of the mathematics education lesson. For each of the five core values which underpinned this research study, descriptions below indicate whether the students believed that the lecturer was, or was not, living out each respective value.

## 5.1 The value of respect

The video recording indicated that I gave my students time to settle before they were expected to pay attention at the commencement of a lesson. Throughout the lesson I waited for students' attention before giving an instruction or explanation. There appeared to be evidence of mutual respect between myself and the students, as evidenced by the fact that I accepted all comments without criticism. I probed for further clarification when necessary, and guided students' thinking towards a correct solution.

The solution process of the mathematical problem received as much emphasis as the solution itself. The solution students 'arrived at' for each problem was respected, and I asked for volunteers to explain their solution process to the class. By asking the students for their opinions, I intimated that their opinions counted, and I used their

responses to guide them towards appropriate teaching strategies – within the content and the context – of the problem under discussion.

An incident occurred during a lesson in which a student, who had previously given feedback to the class, showed disrespect to a fellow student by being disruptive during a class feedback session. I dealt with the situation by reminding the offending student that his fellow students had given him their attention during his feedback opportunity, and asked him to do the same. The student immediately gave his attention to his fellow student who was giving feedback to the class.

## 5.2 The value of fairness

In terms of the value of fairness, I attempted to give all students equal attention and support in their endeavours to solve problems, and all groups were given opportunities to give feedback regarding the solutions to respective problems. I encouraged class and group discussion by asking probing questions and asking students' opinions of specific answers to problem-solving activities.

In order to give students multiple opportunities to master mathematical concepts and skills, I endeavoured to display patience and respect during my interaction with them.

I purposefully did not prescribe that students should use a particular problem-solving strategy in order to solve a problem, and I encouraged them to use their own strategies for solving problems. I accepted all strategies used by students, provided they were mathematically correct. As a class activity, we would then investigate various problem-solving strategies used to establish whether students regarded them to be effective and efficient.

Students were then at liberty to refine or change their strategies if they found other strategies to be more relevant than their own selected problem-solving strategy. I believed that it would be unfair of me to insist on a particular problem-solving strategy, as in 'real life', problems can be solved in diverse ways. Students were appreciative of this teaching methodology.

I ensured that I gave students sufficient time in which to solve problems collaboratively, and then checked that the majority of the students had reached a solution, before asking group representatives to give feedback to the class.

### 5.3 The value of accountability

In terms of the value of my personal accountability, the video-data indicated that I was well prepared, well organised, and created a classroom climate that was conducive to inquiry-based teaching and learning. I used different strategies to ensure that students were able to grasp the content knowledge and skills under consideration. I moved from one group to another to check that students were 'on track', and quoted information from acknowledged literature sources. This approach gave credibility to the information being disseminated.

In terms of student accountability, I expected the students to take responsibility for their own work. Although willing to guide by asking probing questions, I made explicit the fact that I expected them to work collaboratively in solving each given problem, and to take ownership of their participation. Students were requested to volunteer explanations as to how they had solved a particular problem; and fellow students were encouraged to ask questions after the explanation had been given.

Once there were no further questions from students, I would request permission to ask questions which would further clarify the solution process. If the volunteer student had explained incorrectly or given an incorrect solution, I gave them an

opportunity to correct their answers, rather than asking other students to correct work that was not their own.

## 5.4 The value of honesty

Although the value of honesty was one of the core values underpinning this research study, it was very difficult for me, while observing the video recording of my lesson on problem-solving, to identify instances in the lesson where I was living out the value of honesty in the classroom situation. However, evidence from the students of how I attempted to live out the value of honesty in my engagement with them, has been forthcoming from the discussion of both student journal entries and interviews.

## 5.5 The value of compassion

In terms of the value of my compassion towards students in my mathematics education classes, I attempted to create a relaxed, non-threatening classroom climate in which learners would be encouraged to participate actively and enthusiastically. From observation of the video lesson, I believe that my body language displayed evidence that I listened carefully to responses and comments made by students.

Evidence also included positive communicative strategies of a friendly countenance, eye contact, encouraging tone of voice, forward positioning of body, nodding of head and allocating sufficient time for student responses.

The video representation showed evidence that I endeavoured to understand the difficulties experienced by students and attempted to guide them towards experiencing success in the problem-solving activities. At times, I asked specific students if they would like to give feedback on the solution to their problem. If they indicated that they were not comfortable to give feedback, I respected their decision by asking for volunteers.

An incident occurred when a student volunteered for a fellow student to give feedback to the class. I explained to the class that they were only permitted to volunteer their own services – and not those of their fellow students. I explained that I saw this as a lack of compassion on a fellow student who may have found it extremely uncomfortable to speak to a class of students.

## 6. SUMMARY

Both qualitative and quantitative methods were used to generate the data in this study. Quantitative statistical data and qualitative data were generated from the pre- and post-intervention affective-disposition statements, pre-, mid- and post-intervention interviews, and student reflective journals. Further qualitative data were generated from the video recording of a mathematics education lesson in action. Quantitative methods provided statistical data, while the qualitative data were organised according to broad themes to provide descriptive and inferential statistics.

These data were analysed and used for comparison, where applicable, between the two groups of participating students, viz. first-year mathematics and science students and second-year language students, all of whom were registered for their first mathematics education course for their B Ed degree studies.

Attention is drawn to the positive correlation between student mathematics self-efficacy and opportunities given to students to experience success in mathematics activities. Statistical quantitative findings indicate that both groups of participating students showed an increase in mathematics self-efficacy levels from pre- to post-intervention. However, the group of first-year mathematics and science students showed significantly higher levels of mathematics self-efficacy throughout the study than did the group of second-year language students.

Inquiry-based teaching and learning strategies are highlighted and the significant role these played in allowing students opportunities for developing confidence and improving self-efficacy levels. Tables, graphs and descriptive text were used to represent the data collected by the use of the affective-disposition statements, reflective journals, interviews and the video recording of a mathematics education lesson.

The data generated will be discussed in Chapter Five, while the implications of the findings will be interrogated in the final chapter of this thesis.

# CHAPTER 5

# DISCUSSION

## 1. INTRODUCTION

In this chapter the results and findings presented in Chapter Four are discussed within the context of the theoretical framework presented in Chapter Two. The discussion is guided by the research question and the subsidiary research questions of this research study. The degree to which the objectives have been realised will be examined and the results obtained will be discussed. The categories developed from the quantitative statistical analysis and the descriptive qualitative data in Chapter Four are related to the theoretical underpinnings noted in Chapter Two – in an attempt to provide answers to each subsidiary question which underpins the primary question.

The questions answered are: "Did I manage to live my values in my mathematics classes?" "Did my behaviour contribute to a sense of trust in my students and a shared belief in my notion of excellence?" and "How did my approach contribute to achieving the conditions required for a complex learning community of students?" Finally, I answer the question: "Did my approach influence my students' sense of mathematics self-efficacy?"

Possible implications of the findings for curriculum reform, and for the teaching and learning of mathematics within a complex learning community are discussed; and the international view of re-inserting a focus on values and on using a values-based approach in mathematics education are highlighted. The profitability of using the 'new

scholarship' approach in the context of promoting values and self-efficacy in mathematics education is interrogated.

## 2. INTRODUCING VALUES IN MATHEMATICS CLASSROOMS

Haydon (2006) states that in teacher education, as much as anywhere, our society is far from homogeneous in its values. He asserts that students come into teacher training with values of their own, but this does not necessarily mean that they have thought a lot about these values, that they can readily articulate or defend them, or that they know how to respond when encountering others with contrary values.

For this reason, I believe it was important that in-depth engagement around values in education with my students should be the starting point of this research study. However, McNiff (2008) warns about the complexity of turning discursive practices (talking about values) into social practices (living the values).

In the case of this study, the challenge was to transform my own and my students' discursive practices regarding the values of respect, fairness, accountability, honesty and compassion into social practices which would permeate and become an inherent characteristic of our mathematics education classes.

The fact that social situations often involve people who hold different values was clearly apparent within my mathematics education classes. The heterogeneity of the group resulted in much discussion around whose values should be accepted. The way in which the students and I engaged with this issue is considered in the light of the literature review and the results presented in Chapter Four.

The literature review in Chapter Two clearly suggests that the core values agreed upon by the Education Faculty at the NMMU, and which were made explicit in my

mathematics education classes, are shared widely across numerous cultures, religions and races (Fagan, 2003; Kidder, 2005; Haydon, 2006; Nieuwenhuis, 2007). After initial class discussions and debates on the core values, as recommended by Nieuwenhuis (2007), I felt satisfied that 'our' core values also reflected the views of the community of students participating in this research study, and that the discursive investigation of core values could transform into social practices in the mathematics education classes.

However, a journal entry made by a student later in the semester read, "*Everyone has different values so you can't just teach your own values*". This suggested to me that not all students had readily taken ownership of the core values discussed, an insight which drew my attention to the following issues. Firstly, Kidder (2005) warns that some students may accept core values cognitively – without having any intention of practising them. Secondly, Pastoll's theory (2002), which is supported by Haydon (2006), asserts that values cannot be imposed on anyone, but that values need to be internalised with students.

It became apparent from our classroom discussions that some students initially saw little connection between their values and beliefs, and their engagement with the mathematics education module. Although the process of introducing students to the topic of values, and facilitating discussion and debate around this topic, was carefully planned – in an attempt to minimise perceptions of imposition or the 'teaching' of values, the process was evidently still perceived by some students as an imposition, as suggested by the student journal entry described above.

In order to help students to develop and internalise values of their own, I encouraged continuing classroom communication on the issue of a values-based approach to teaching and learning. My expectation was that students who believed in

the class values would be able to successfully defend them with reasoned arguments, and which included possible limitations.

## 3. LIVING VALUES IN MATHEMATICS CLASSES

Haydon (2006) believes that the teacher's example cannot be underestimated in the process of the transmission of values. This author asserts that there is a long-standing expectation in many countries that teachers will stand for, and transmit, certain values on behalf of the wider society. There is an expectation that teachers are to be moral guides and exemplars, whose standards perhaps ought to be just a little above the level of the rest of society.

However, he believes that many young people going into teaching today do not see themselves in this role at all. Instead they see themselves, perhaps, as developing children's mental capacities, not as inculcators of moral rules or preachers of virtues. My experience with pre-service teachers, in many cases, confirms Haydon's theory and strengthens my belief in the importance of implementing a values-based approach with students for the purposes of promoting a culture of values in the teaching profession, instilling a notion of excellence, and for the purposes of influencing students' levels of self-efficacy in mathematics.

As mentioned earlier, my ontological values inspired my reasons and purposes for this research study. It was important to me that my students felt that I actually modelled the core values underpinning this study. Mid- and post-intervention interview data, journal responses, and inspection of the multi-media recording of my mathematics education lesson, suggest that my students believed that I was living out the core values adopted by my class. Not only did they recognise the importance of my practising core

values in our classes, they also recognised the importance for themselves, as future teachers, of practising these values in their own classroom situations.

The first formal journal entry required students to give reasons why they believed/did not believe that a values-based approach to teaching would be of benefit in their mathematics education classes. A third of the student responses suggested that they believed it was important for them to be equipped with the skills of role-modelling values for learners in their own classes. Their desire to be role models who practise their values, rather than being mere 'providers of information', is in line with Nieuwenhuis's stance (2007).

This view states that we cannot give or teach values to others, we can only impart values by setting an example – which others may take up, or reject.

The students' journal entries and interview responses suggest that they believed that values play an important role in developing a climate of respect and trust in a classroom situation; which in turn, leads to an environment that is conducive to learning. They further believed, as quoted from their journal entries, that "doing well comes naturally if you exercise the right values".

Pastoll (2002) makes mention of a research study to investigate the motivational forces of top achievers in various fields of study. The single most dominant factor was that every one of these people had a significant adult who believed in them and exuded a 'quiet confidence' in their capabilities and prospects. Pastoll, therefore, encourages all educators to focus on what students can do, rather than to dwell on what they cannot do.

It is for this reason that I intentionally 'believe the best' of my students, as I endeavour to be the 'significant adult', who believes in them and exudes a 'quiet

confidence' in their capabilities and prospects. My attempts to 'believe the best' of students were acknowledged by students in their journal entries and interview responses, as indicated in Chapter Four.

Considering the diverse educational backgrounds of the students in my mathematics education classes, and according to the data findings, a strong possibility exists that many of the students had no previous experience of a significant adult who had believed in them. I was, therefore, committed to demonstrating confidence in my students' cognitive ability, as well as in their role as teachers.

Question eight of the mid- and post-intervention interviews required students to specify which values, if any, they believed their lecturer was living out in her mathematics education classes. They were further asked to qualify their responses with explanations which demonstrated how each value was being practised. Ninety-nine percent of students believed that the implementation of a values-based approach was making a positive contribution to their engagement in mathematics education.

Students' perceptions of how the five core values were being 'lived out' by the lecturer, as well as positive and negative comments made by students, are discussed under the following headings of each respective core value.

### 3.1 The value of respect

The Universal Declaration of Human Rights states that education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms (Nieuwenhuis, 2007). Nieuwenhuis states that education should, therefore, prepare learners to take responsibility for the life of a free society, in the spirit of understanding, peace, tolerance, equality, and friendship among all peoples, ethnic, national and religious groups and persons of indigenous

origin. Haydon (2006) believes that the value of respect is so widely used, in so many contexts, that we rarely stop to reflect on what it involves.

He suggests that respect could include: self-respect and self-discipline, respect for others, respect for the privacy and property of others, respect for religious and cultural diversity and respect for the environment. He further advocates that respect for people and recognizing the moral worth of every person is central, while everything else derives from that.

For the purposes of this research study the focus was on recognising the moral worth of every person and the belief that all other forms of respect would be derived from practising this moral value.

Brooks and Brooks (1993) emphasise the importance of seeking to understand students' points of view. They describe students' points of view as windows into their reasoning, and hold that valuing students' points of view means not only recognizing them, but also addressing them, making school experiences both contextual and meaningful (Llewellyn, 2005).

The interview responses indicated that ninety-eight percent of the respondents believed that I was living out the value of respect in my classes. A dominant theme of 'mutual respect' emerged from these responses, as being the key for the successful practice of the value of respect within the classroom situation. Statements presented in Chapter Four include, amongst others: "*There is mutual respect between the lecturer and the students*"; "*the lecturer listens to the students"* and "*she expects students to listen to each other*".

The students' journal responses to formal prompt two, as well as their interview responses, indicate that they enjoyed the co-operative learning strategies that were implemented in the lectures and felt that they benefitted from the group discussions. They said that they found the activities interesting and interactive, and they enjoyed feeling included and involved in the mathematics education classes.

They appeared to interpret the inclusiveness of the classroom climate as a form of respect for their ideas and opinions. The majority of students indicated a positive response to inquiry-based principles and made specific mention of the fact that they appreciated that their ideas and opinions were listened to and valued. Llewellyn (2005) asserts that the foundation of inquiry-based learning is when students are empowered by the feeling that their teachers and peers value their ideas, thoughts and opinions.

A student journal response given to formal prompt two, which required them to describe what they had enjoyed and what they had not enjoyed about the mathematics lectures was, "I am afraid to ask questions because I think that other students will laugh at me or think that I am stupid". I provided an encouraging written response in this student's journal and facilitated a class discussion to give the class an opportunity to express their opinions regarding intimidation and the possibility of ridicule by fellow students.

Their discussion lead them to agree that the practice of ridiculing fellow students was a contradiction of the value of respect, which was one of 'our' core values that we had agreed to practise in class. The students agreed to the principle that no-one would show any form of ridicule to fellow students in our mathematics education classes. I explicitly committed to modelling and upholding this principle; and I believe that I was

able to use my educational influence to encourage students to practise the value of respect with their fellow students.

However, in spite of verbal and written encouragement, twelve percent of students still indicated in subsequent journal entries that they continued to feel vulnerable during class discussions and were still too nervous to ask questions in front of the class of students. Despite these expressions of perceived vulnerability, the overall student responses and classroom experiences described in Chapter Four suggest that teaching and learning gains were made in my mathematics education classes, and that a values-based approach could have a significant role to play in mathematics teacher education programmes.

My challenge was to continually strive to create conditions which would enable students to feel sufficiently comfortable to ask questions when the need arose. I believe that a trust relationship develops over time, and should fellow students consistently display respect for each other, a value of respect, leading to trust, could create a safe, secure classroom atmosphere in which they would be able to influence each other's self-efficacy levels.

### 3.2 The value of fairness

Student responses to the value of fairness were mainly concerned with class discipline issues and fairness related to English as the medium of instruction for classroom communication. As described in Chapter Four, I responded to these issues by facilitating class discussion – in order to clarify any misconceptions or incorrect perceptions that they may have had with regard to agreed-upon codes of classroom conduct and the university language policy.

Student responses with regard to question eight of the interview processes in which they were asked to describe ways in which I was practicing or not practicing the value of fairness, indicated that ninety-four percent felt that I 'lived out' the value of fairness in my classes.

Two broad themes emerged from the student responses, indicating ways in which they believed that I was practising fair behaviour in the classroom situation, namely: '*Discipline and classroom climate'* and '*teaching ethics and strategies'*. Within the theme of '*discipline and classroom climate'* they indicated that I had set fair and negotiated boundaries to maintain discipline in the overcrowded classrooms; and they believed that students guilty of infringement of these conditions had been dealt with fairly.

A situation arose in which a group of students ignored my request for their attention – in order to address them at the beginning of the lecture. Pastoll (2002) clearly advocates that being tolerant of someone does not mean that one has to put up with behaviour that is counterproductive, disrespectful or disruptive of others. I twice requested their attention, but they failed to respond. I then asked the offending group of students to leave the lecture room – a collaboratively agreed upon, fair consequence of disrupting a mathematics education class.

The group of students reluctantly left the lecture venue. One of the students believed that I had acted unfairly towards him and sent me an e-mail to express his feelings of anger at the unfair treatment inflicted on him. I responded to his e-mail, explaining that I did not feel that it was appropriate to respond to his accusations by e-mail, and requested that he make an appointment to see me at his earliest convenience so that we could discuss the matter concerned.

The student did not respond to the e-mail and failed to attend the following mathematics education lecture. I sent him a further e-mail requesting that he meet with me to discuss the perceived unfair treatment he had received. Again he chose not to respond to the email. Lecture sessions then came to an end, as formal semester examinations had commenced.

After the students had completed the mathematics education examination, which I invigilated, I requested that this particular student meet with me to resolve the conflict situation that had arisen. He complied, and during the discussion he was initially fairly aggressive and resolute in his perception that he had been unfairly treated. I apologised for the fact that he felt that he had been unfairly treated and asked him to clarify his perceptions of the unfair treatment meted out to him.

I remained calm and respectful of his explanations throughout and allowed him sufficient time to express his anger at his perception of being unfairly treated. I then requested an opportunity to explain the stance I had taken. After much discussion, deliberation and debate, we agreed that we had both gained a deeper understanding of each other's perspective and the stances respectively taken in the conflict situation.

Once the conversation had run its course I thanked him for giving me the opportunity to discuss the situation. He apologised for the accusations he had made, and I said that I was sorry that he had perceived that I had treated him unfairly. I believe that we both learnt a number of valuable lessons as we discussed our respective perceptions of what had transpired during the conflict situation.

According to Kidder (2005), conflict is constructive when we are able to exchange views and encourage new ideas. When it is destructive it undermines what people are trying to do and the people who are trying to do it. I believe that we both

emerged from the discussion with our integrity intact; and therefore, I believe that the conflict situation described above was resolved constructively. We were both willing to modify our views and the conflict was resolved in an ethical, rational and constructive manner. Kidder (2005) describes 'ethical' as taking action that accords with the core values, and having the positive courage to be ethical in the face of adversity. This may be defined as moral courage.

He further believes that moral courage enables us to face up to problems, yet not necessarily always resolve them.

The classroom incident described involved a particularly difficult period in my career as a teacher educator. Interrogation and reflection on the incident enabled me to place the incident in some kind of context. Relating the incident in my personal journal enabled me to reflect with some clarity and perspective into the possible reasons why the incident had taken place. The opportunity to write and reflect brought some enlightenment and enabled me to discuss the conflict situation with the student concerned within a framework of moral courage, as described by Kidder (2005).

### 3.3 The value of accountability

Haydon (2006) describes accountability as the value of being responsible to others in society for our individual behaviour; while McNiff (2008) asserts that each person needs to hold themselves accountable for how they interact with others. All of the students in both the second and third interview sessions responded that they believed that I lived out the value of accountability in my interactions with them. However, a situation arose in which it became apparent that some students had not internalised the value of accountability, as they chose to submit assignments in which they had merely fabricated a written report of a lesson that they had not actually taught.

According to these students' own admission, they had not been adequately prepared for their lessons and their 'number card' teaching and learning aids were not of the required standard. I was disappointed that they were thereby failing to practise the value of accountability. Before students finalised their sets of the number-card apparatus, I invited them to allow me to check them – so as to ensure a high standard of teaching apparatus.

I explained to the students that they were accountable to the learners they were going to teach, to ensure that their sets of number cards were both professionally presented and accurate. In turn, I explained that I was accountable to the schools in which they would 'practise-teach' for the accuracy and professionalism that they manifested.

A common theme that emerged from student responses to questions on the ways in which the lecturer was living out the value of accountability was *'the lecturer's ethics and teaching strategies'*. They indicated that they believed that I had displayed the value of accountability by my punctuality, reliability, honouring my word, upholding the class boundaries that had been negotiated and agreed upon, and returning assessed work promptly.

By doing this, I believe that I took cognisance of Pastoll's caveat (2002) that students who are kept in a state of anxiety for weeks after a test has been submitted have diminished opportunities of developing confidence in relation to that particular section of their work.

### 3.4 The value of honesty

Pausch (2008) advocates that honesty is not only morally right, but also efficient; since in a culture where everyone tells the truth, double-checking would not be

necessary. He believes that people often lie because it seems like a way to get what you want with less effort – a short-term strategy that turns out to be ineffective in the long term.

Banner and Cannon (1997) observe that teachers who are best remembered are "*Those who knew their subjects well and transmitted them with the greatest intensity and love. They were confident in their knowledge, and not dogmatic. They stood before us to present the act of learning with a sort of honesty that we rarely encounter in everyday life. It is such examples of passion and exhilaration that students need in their teachers" (pp. 15-16).*

Part of this honesty is a genuine humility about our own practice and what we do when we fail in our attempts to practice what we preach. As university teacher-educators, we are continually modelling teaching to our pre-service students. My students were invited to continually critique my values-based approach to teaching, and I was regularly afforded 'doses of humility and realism', which emphasized how hard it is to be an effective teacher.

This gave me, and the students, opportunities to engage in joint reflection about practice. I had the opportunity to model vulnerability and collaborative reflection, and to hopefully instill a similar commitment in them. Many gaps between the ideal and the reality of practice were discussed and debated. Intrator and Kunzman (2009) claim that more than anything, when we stand before our student teachers, we hope to convey that teaching is about the ongoing investigation of practice, and about how we, as teachers, are in the process of ever evolving.

All participating students agreed that I lived out the value of honesty in my relationships with them, and their responses could be organised into two broad themes,

namely: '*Discipline and class atmosphere'* and '*teaching ethics and strategies'*. They indicated that they believed that I was practicing the value of honesty by being true to my word, admitting and apologizing when I made a mistake, giving honest responses in journal entries, and by being judged to be sincere in wanting them to achieve.

I believe that the students' faith in my honesty promoted a relationship of trust, which in turn, helped to create a classroom atmosphere that exalted integrity.

### 3.5 The value of compassion

During the mid-intervention interview, when the question relating to the lecturer's practice of compassion was first broached, many of the students responded with the incorrect understanding that the interviewer was referring to 'passion' rather than 'compassion'. Many students did not understand the meaning of the word 'compassion'. The interviewer then ensured that there was clarity regarding the terminology before continuing with the interview.

The mid- and post-intervention interviews indicated that 95% of the students believed that I had displayed the value of compassion when relating to them in my mathematics education classes. Five percent of the students suggested that, because they perceived that my life experiences had been very different from their own, they doubted whether I would be able to empathise with their cultural and historical backgrounds and show compassion for the way in which their respective backgrounds had led to the development of their present negative attitudes to mathematics.

This issue, highlighted mainly by students from previously disadvantaged backgrounds, signals the importance of a focus when implementing teaching and learning activities, which develop confidence and enjoyment in mathematics, and which can influence confidence levels and improved levels of self-efficacy in mathematics.

I was grateful for the students' honesty and was able to reflect on the comments made by them in this regard. I have many years of experience in teaching at disadvantaged schools and working in poverty-stricken areas, but my formative years were spent in a secure environment and I have enjoyed a good education at a previously advantaged school. I now acknowledge that I need to purposefully investigate the home and school conditions of as many students as possible – in order to reach a deeper understanding of their perceived beliefs and understandings.

As I reflected on my own personal history, it enabled me to gain some insight into my implicit theories – those ideas that had shaped my notions of what teaching and learning are all about.

Comments were made by a student regarding the large class sizes which were accommodated in mathematics education lectures. She believed that overcrowding in the classroom situation prevented her from experiencing personal compassion from the lecturer. The large numbers of students in classes have also been a challenging aspect for me in conducting this research study; and I felt that the opportunities of getting to know my students personally had been thereby hindered.

Responses from the mid- and post-intervention interviews regarding my practice of compassion could be organised into two dominant and broad themes, namely: *'Discipline and class atmosphere' and 'teaching ethics and strategies'*. Firstly, the students indicated that I had shown compassion in terms of discipline procedures, the creation of a caring classroom atmosphere, moral teaching, ethics, and effective teaching strategies.

Secondly, they mentioned the value of my written feedback in response to the entries they had made in their journals, with one student noting that, *"she understands us and takes our feelings into account when responding"*.

The second formal prompt required students to reflect on what they had enjoyed/not enjoyed about lectures. More than a quarter of the students mentioned that I was "caring and patient", and that they valued the fact that I had made myself available, outside of lecture time, for consultation. I took cognisance of the responses of the four percent of students who commented on their need for me to slow my pace in covering curriculum content.

I made mention of this in class, and said I would be conscious of this and that students should remind me if they felt that the pace of dealing with concept knowledge and skills in class was too hurried.

### 3.6 The value of integrity

Integrity, as described in Chapter Two, is the ring that binds together the core values which revolve around the notion of trust, as the fundamental condition for a trustworthy and effective framework that promotes social cohesion amongst a community of mathematics education students. The findings of this research study suggest that progress was made in fostering a climate of integrity within the mathematics education classes.

Without the continued purposeful recognition, acceptance and practice of the five core values which underpin this research study, I believe that the desired classroom climate of integrity, which incorporates these core values, would have remained an unattainable goal. For this reason, I believe it was important for me to address issues

which appeared to be in contradiction of the core values we were trying so hard to uphold.

Many of these incidents have been described in this research study, and, in most cases, I believe that there were positive outcomes for the students and myself as opportunities for discussion and debate on the importance of implementing values within the classroom situation presented themselves.

## 4. BUILDING RELATIONSHIPS OF TRUST

Question ten of the mid- and post-intervention interview processes required students to describe ways in which I had succeeded, or not succeeded, in developing a trust relationship with them. The verbatim responses of students to this question suggest that I had succeeded in inspiring a sense of *trustworthiness* in the students. Trustworthiness is defined by Kidder (2005) as the manner in which an individual acts in order to engender trust and merit the confidence of others.

As a lecturer-researcher, I attempted to display trustworthiness by inspiring my students to feel confident in, and rely on me, by firstly, extending a sense of trust to others so that they would trust me (Kidder, 2005). Trustworthy behaviour, according to Kidder, is predictable, clear, honourable and honest; and he further explains that trust is an emotional strength that begins with the feeling of self-worth and purpose that we are called on to extend outward to others, like the radius of a circle.

Kidder describes the warm, solid ‘gut feeling’ you get from trust – from counting on yourself and in trusting and being trusted by others – as one of the great enablers of life.

All student responses for both the mid- and post-intervention interviews suggested that they felt that they had developed a sense of trust in me. Journal entries and interview responses indicated that the development of a trust relationship related partly to students' perception of my personal commitment to both students and teaching, but predominantly to the fact that I had responded to every journal entry they had submitted within a two-day period of time, as promised.

Students indicated that they found my journal responses to be encouraging, honest and non-critical. Students said that these written communications had made them feel that I had a personal interest in them. In their journal entries, students also affirmed their belief that I 'believed the best' of them and also 'wanted the best' for them.

Journal prompt two required students to indicate what they enjoyed/did not enjoy about their mathematics education lectures, and one third suggested that they enjoyed the 'feeling' that their ideas and opinions counted and were valued. It was these responses, in which students suggested they trusted that I would not ridicule or ignore their contributions to the learning process. This prompted me to believe that 'valuing the opinions of students' had played an important role in the development of our student-lecturer trust relationship.

This supports Llewellyn's theory (2005) of encouraging student inquiry, as active participants in the learning process, as well as Brooks and Brooks' model (1993) of building a classroom community by getting students to believe that their ideas count and so influence their self-efficacy – and promote a trust relationship within a learning community.

A particularly large number of students were registered for the first mathematics education module (PICM 201) of the degree course, and the university did not have sufficient venues to cater for the recent increase in student registrations. This created a real challenge for me personally and for the implementation of a values-based approach and inquiry teaching.

An incident occurred during a mid-semester test in our mathematics education class which appeared to threaten the value of trust which we had worked so hard together to establish and maintain. A test was being written in a venue which was inadequate and did not allow for sufficient space between the students. A long narrow table at the back of the lecture venue was shared by four students who sat in close proximity to each other.

I explained to all the students that the testing conditions were not favourable for adequate personal space and requested them to keep their work covered during the writing of the test, either with their question paper or a clean sheet of A4 paper. As students focused on writing the test, many of them forgot about keeping their work covered, and as I walked amongst them during invigilation, I continually covered their work with their question papers.

As the test writing progressed, I felt pleased with the way in which the students had responded to the less-than-adequate testing conditions and commended them on their mature, accepting attitude of a less-than-ideal situation. Once all the test papers had been collected, one of the students who had been sitting at the long, narrow table at the back of the lecture venue approached me. She engaged me in the following conversation which I then recorded soon after the event.

*Student: I did not appreciate the way you said that you did not trust the students at the back table.*

*Lecturer: I don't understand what you are getting at.*

*Student: You said that you don't trust the people sitting at the back table.*

It was difficult for me to accept that I may have indicated to the student that I did not trust her, yet I realised that this is what she had 'heard' when I requested that students should keep their work covered during the course of the test. The student was adamant that I had used the words: '*I don't trust you*'. I was initially very disappointed with the attitude of this student, which I perceived to be rather aggressive, and I felt disturbed and demotivated by this unfortunate and unpleasant incident.

I soon came to realise that this situation could not easily be resolved, as we each had different perceptions of what had actually occurred in the lecture venue. It was important to me that I 'lived out' the values which underpin my belief system, and in order to show compassion and respect to this student, I apologised for the fact that she perceived that I had mistrusted her.

I gave her a hug to show the sincerity of my apology. Her eyes filled with tears and she left the class far less belligerent than when she had approached me after the test. This was not the first time that this particular student had shown an aggressive spirit in the class situation; and I believe that my sincere apology and humility influenced her attitude, and that she had learnt some meaningful conflict-resolution skills. It certainly gave me an opportunity to reflect on any negative messages students may receive in spite of honourable intentions.

I believe that I displayed moral courage by putting my values into action in the face of adversity, and as Kidder (2005) advocates, I found that moral courage enabled me to face up to the problem – not necessarily to resolve it, but to address the problem squarely and with determination. Kidder questions what good a conviction on values is without a willingness to put those values into action – in the face of adversity.

Nieuwenhuis (2007) recommends that educators should live according to the agreed values they teach, and set an example that students can emulate. The opportunity to put my values into action in the face of adversity was not a comfortable experience, but one that I believe may have positively influenced this particular student's consideration of a trust relationship with me.

Kidder (2005) asserts that moral courage lifts values from the merely theoretical level, and carries us beyond ethical reasoning into principled actions. He further believes that if by ethical we mean taking action that accords with the core values of honesty, fairness, respect, responsibility and compassion, then moral courage, which is the thread holding the core values together, means the courage to invoke and practise those values.

He relates a story where, for the sake of moral courage, a man was expected to allow his own pride to be injured. I felt that I could relate to Kidder's story, as I had to be prepared to forego my own pride – in believing that even though I was not guilty of the student's accusation, I humbled myself to apologise to her. Kidder asserts that when people live in a morally courageous way, it not only elevates their own experience, but also touches others who witness the event or get to hear about it.

It is for this reason that I believe that the students who witnessed the incident, or heard about my apology, may have been positively influenced by the stance of moral

courage that I chose to take. Since that incident I have experienced a more positive relationship between myself and the student who felt that I had indicated an instance of mistrust in her. I have since then developed a heightened sensitivity to my own language, lest I be misinterpreted by students.

Students' verbal and written responses and discussions relating to 'living out' values in mathematics education classes suggest that my behaviour in promoting and 'living out' the core values appears to have encouraged the development of a lecturer-student trust relationship.

## 5. SHARING A BELIEF IN THE NOTION OF EXCELLENCE

The description given for the notion of excellence in Chapter Two defines excellence as a matter of the stand we take that allows for performance to surpass what was previously possible. The White Paper on Education and Training, last modified in 2008, makes specific mention of the need to transform teaching and learning and realise the ideal of excellence for all as a real possibility.

Pajares (2002) advocates that highly regarded teachers who model excellence in their teaching can use their educational influence to encourage self-belief in students and promote personal self-efficacy, thereby giving students opportunities to experience success, which in turn, develops confidence and encourages students to strive for excellence. Student responses to the affective-disposition statements, journal entries, interviews and the multi-media video-recording provide data which suggest that my behaviour contributed to a shared belief in the notion of excellence.

In response to the first formal prompt in their journals, in which students were asked to explain the perceived benefits/disadvantages of using a values-based approach

to their mathematics education studies, a student responded that, "*values will ensure that I become the best student teacher I can be*", while another responded with, "*values will make me the ideal teacher*". In both cases students indicated their desire to reach their full potential and to strive for excellence.

In one of the informal journal entries, a student responded: "*I would like to attend lectures with both groups of students, as I think I am falling behind*". Again this was an indication to me that this student was taking a stand to perform well and demonstrated a positive sense of self-efficacy. As noted previously, Bandura (1994) believes that people who doubt their capabilities have a weak commitment to goals, and that persuasive talk can lead people to exert more effort to succeed.

I trusted that my persuasive talk had influenced a high degree of assurance of this student in his capabilities and had encouraged this positive behaviour. In Chapter Two, mention was made of Bandura's belief (1994) that people who are persuaded verbally that they possess the capabilities to master given activities are likely to mobilize greater effort to succeed, thereby promoting the development of skills and a sense of self-efficacy.

In support of Bandura's theory, I attempted, whenever appropriate, to verbalise my belief in my students' abilities.

Formal prompt three of the journal entries required students to respond to the statement: '*Without self-efficacy in mathematics nothing can be achieved, with it nothing is impossible*'. A student appeared to directly link the notion of mathematics self-efficacy with striving for excellence, as she responded that she believed that the statement was true and stated: "*I always strive for excellence*".

Another student confirmed the saying that, 'success breeds success', by responding with, *"getting good results motivates me"*. As recorded in Chapter Four, eighty-five percent of students responded to this mid-semester formal prompt that their belief in their ability to do mathematics had improved; while fifteen percent of students believed that their self-efficacy had been strong before their engagement in the mathematics education module.

In other words, no student perceived that their ability to do mathematics had decreased. This suggests that using a values-based approach to mathematics education classes had either maintained or improved my students' levels of self-efficacy. The most common response given to qualify an improved mathematics self-efficacy, as mentioned in the previous chapter, was students' enjoyment of mathematics classes. Improved enjoyment levels resulted in student journal comments that they had *"more confidence"; "changed attitudes";* and some resolved to try and *"make their own learners more positive about mathematics"*.

Reasons given by students for developing a more positive mathematics self-efficacy suggested that my attitude was an influencing factor, as they responded with positive statements such as: *"I have been influenced by our values and attitudes"; "the lecturer's positive attitude rubs off";* and *"the lecturer is very enthusiastic about mathematics"*.

In both the mid- and post-intervention interviews, all students affirmed that the lecturer had 'lived out' the notion of excellence in her teaching practice. They cited '*patience, teaching ethics and skills'*, and '*passion and enjoyment of mathematics'* as the most frequent indicators of notions of 'excellence' displayed. Their responses

suggest that my explicit stand for excellence had encouraged them to pursue this approach in their engagement with the mathematics education module.

Their responses support claims by Woolfolk (2004) and Hess (2005), who emphasise the importance of creating opportunities for students to foster the pursuit of excellence.

As mentioned in Chapter Four, references were made to the lecturer's display of notions of excellence in her work, her "love" of her work, and her respect for students. It appears that they recognised these characteristics in my teaching, and in both the second and third interviews, 100% of the respondents affirmed that the notion of excellence, as defined for this study, had been exhibited in the teaching of the mathematics education module.

The students indicated that they were initially motivated to achieve in mathematics education via extrinsic motivation provided by their lecturer. As their motivation levels grew, as indicated by the data generated in this study, intrinsic motivation appeared to play a role in students' growing confidence in their ability to do mathematics and their development of positive attitudes.

My intention was to inspire all of my students to reach their full potential and encourage them to pursue excellence – both personally and academically. As mentioned earlier, Pajares (2002) advocates that highly regarded teachers who model excellence in their teaching can use their educational influence to encourage self-belief in students. I believe that the data generated from my students suggest that my attempts at modelling excellence had a positive impact in influencing improved levels of self-efficacy in my classes.

As the core values had been discussed and debated in class situations, and hopefully modelled by me, many of the students were provided with an opportunity to realise the importance of values – both for themselves personally, and for their teaching success professionally. Fagan (2003) reminds us that these core values traverse cultural and historical boundaries and focus on the responsibility placed on individuals regarding interaction with others.

In an attempt to facilitate the internalisation of these values in my students, I endeavoured to develop a complex learning community, in which my students found the space to examine, interrogate and practise core values, and pursue excellence in my mathematics education classes. My attempts to contribute to a complex learning community of students, in which they would find opportunities to practise core values and pursue excellence, will be described in detail in the next section.

## 6. DEVELOPING A COMPLEX LEARNING COMMUNITY

The literature discussion in Chapter Two reveals that a complex system is greater than the sum of its parts; it is the product of the parts and their interactions – something that is self-organizing and adaptive (Johnson, 2001; Capra, 2002). Conditions required for the development of complex mathematical learning communities were described in detail in Chapter Two, as well as the conditions necessary for influencing levels of engagement, enjoyment and confidence within these complex learning communities.

The results of my attempts to create mathematical learning communities in my classes, and conditions under which students could engage in learning activities in order to promote enjoyment and confidence, will be discussed as I respond to the subsidiary

research question, *'How did my approach contribute to achieving the conditions required for a complex learning community of students?'*

There are five necessary conditions that need to be met for a complex system to emerge and maintain itself (Davis & Simmt, 2003). These conditions, which have been adapted from Bloom (2000), Casti (1994), Kelly (1995), and Lewin and Regine (2000), are internal diversity, redundancy, decentralised control, organised randomness and neighbour interactions.

I will describe the way in which I believe these conditions were best met in this research study under each of the five respective conditions. Together, these foster a complex learning community.

## 6.1. Internal Diversity

Internal diversity reflects the different ways in which members of a community can respond and interact. In this research study it refers to the interaction of both values and mathematical knowledge. According to Davis and Simmt (2003), communications in a students' collective consist of different individual contributions, the eventual insight belonging to the community, not to any one individual. For this reason, it was important that core values were highlighted for, and interrogated by, students within the class.

A further characteristic of internal diversity within a community of students is that diversity must be accepted and respected by the students themselves. I therefore encouraged my students to ensure that all group members were given opportunities to contribute to the discussion. To ensure that all students remained actively engaged in the group activity, they were not told beforehand which particular group member would be asked to give feedback to the class regarding the group response.

The use of journal entries in mathematics education classes allowed students opportunities to express their flexible and varied responses. Anonymity encouraged openness and honest responses from students, and enabled me to develop a sensitive awareness of students' diverse thinking, opinions and expectations. My role in using journal prompts was to 'hear' the students' opinions, comments, frustrations and concerns – and to respond meaningfully to their unique and diverse modes of communication, encourage a student-lecturer trust relationship, encourage the implementation of core values, and enhance their levels of self-efficacy.

Many of the student responses indicated that they found the use of journals in their mathematics education classes to be a motivating factor in the reflection and internalisation of values and the role they play in contributing to social responsibility and social cohesion in the community of students.

The students worked co-operatively on a regular basis – sometimes being assigned to a specific group, and at other times organizing themselves into groups. A number of students indicated in their journals and during interview procedures that they generally enjoyed the co-operative learning strategies that were implemented in lectures; and felt that they had benefitted from participation in the group discussions.

Students commented that they found the activities interesting and interactive and they enjoyed feeling included and involved in the mathematics education classes. As previously mentioned, students intimated their appreciation that their ideas and opinions were being listened to and valued. The regular use of co-operative learning strategies, where their diverse ideas were heard and treated respectfully, appeared to have a profoundly transformative effect on participants' beliefs about the teaching and learning of mathematics.

It was encouraging to note student-journal responses, which indicated that they felt “the positive attitude of the lecturer enabled them to feel comfortable with participating in class”. This suggests that a relaxed, non-threatening atmosphere, as needed for amicable and optimal internal diversity, had been developed. Some students, however, indicated that they preferred to work alone, and had to be encouraged to make collective contributions.

The heterogeneity of the students within the class was valued, and our agreed-upon principle of accepting all student contributions for consideration seemed to play a significant role in promoting self-efficacy, as students felt that their opinions were valued. However, some students still appeared to be cautious about making collective contributions - possible reasons being that they had not yet developed sufficient confidence in the trust relationship amongst the students and the lecturer, and that their contributions to the collective might be ridiculed – or even dismissed.

Student responses to formal prompt four, which asked students what they enjoyed most about the problem-solving activities done in class, indicated that “solving problems in diverse ways” was one of the most frequent responses given. Students indicated that being able to use different strategies for solving problems was a new and enjoyable experience for them. The diverse ways that students chose to solve problems also provided opportunities for internal diversity, as a necessary condition of complex learning communities.

Most students’ school experiences appear to have been cases of using only the ‘teacher’s method’ or accepted formal algorithms for solving given problems. From observation and student comments, I believe that the enjoyment experienced by students fostered increased confidence in their mathematics ability and enhanced the

development of their reasoning skills. Students also responded that they found mathematics education classes to be interesting and fun, and viewing mathematics from a teaching perspective was also an exciting new experience for them.

Another frequent response given to formal prompt four was "*enjoyment and success experienced*" during collaborative problem-solving activities. According to the student responses, the introduction of co-operative teaching and learning strategies appeared to promote the levels of interaction and enjoyment of the students. Co-operative group work appeared to foster a sense of community, as students felt included and valued.

I therefore encouraged students to build on one another's ideas by probing each other's thinking. As previously mentioned, the majority of the students participating in this research study had not been exposed to interactive-learning experiences during their own schooling, where diverse notions were entertained. For this reason, I provided many opportunities in the classroom situation for continually focusing on inquiry skills that accommodate diversity – in an attempt to promote levels of interaction and enjoyment, and thereby influence their level of self-efficacy in mathematics.

## 6.2. Redundancy

As described in the literature review, redundancy is the complement of diversity, i.e. redundancy is the 'sameness' of the individuals within a system. This 'sameness' in a learning community may be a factor of knowledge, purpose, background, etc. Davis and Simmt (2003) describe the condition of redundancy as the similarity of individuals within a complex learning community of students. They assert that members of a successful community of students (in this case a class of mathematics education students) need a degree of 'sameness', for example, culturally and educationally.

Having similarities, they believe, is essential in triggering a transition from a collection of 'me's' to a collective of 'us'.

A complex system's ability to maintain coherence is, therefore, connected to the redundancy amongst its members. Redundancy therefore enables interactions amongst members and compensates for members' failings within the community of students. An important aspect to redundancy, as explained by Davis and Simmt (2003), is the importance of organising communities of students according to common ground, such as language or compatible experiences, in order to promote interactivity in the complex collective.

I soon realised the importance of this aspect of redundancy, as I erroneously attempted to promote social connectivity amongst students by encouraging widely heterogeneous groupings of students. My experience was that there was an 'awkwardness' within such a heterogeneous community of students which I did not observe within groups where students of similar language, schooling and social backgrounds organised themselves into homogeneous communities.

Given the freedom to form their own groups, students tended to organise themselves into homogeneous groups with regard to language and culture, within which the group atmosphere seemed to promote interaction. I realise that this approach to group formations within a complex community has its own problems, but can be useful as an initial approach. However, I came to realise that our continual conversations around our shared core values played a role in fostering coherence amongst students and promoting the degree of redundancy within our complex learning community. This was needed to promote meaningful exchanges of diverse ideas.

## 6.3. Decentralised control

Decentralised control is an empowering condition of complex learning communities, as it allows for power and authority to be distributed. According to Davis and Simmt (2003), the distribution of sharing authority across the classroom community is not a matter of 'anything goes'. They further explain that with the emergence of any complex collective, standards of acceptable response and acceptable activity – of rightness and wrongness – inevitably arise.

As mentioned in Chapter Four, many students responded in their journals and during interviews that they were frustrated when a few students did not adhere to the values of the code of conduct, and that they were a distracting influence to other students in class. This suggests that a number of students had a sense of ownership of the core values, and were frustrated that their peers were resisting the status quo by not upholding the values-based approach.

A class discussion ensued, as I wanted to be sure that 'our' core values for the mathematics education classes reflected the collective views of the community of students participating in this research study. After much debate and deliberation, consensus was reached – that students participating in the research study could only take responsibility for their own behaviour – and one could not enforce a values commitment on other students.

I believe that this class discussion facilitated a distribution of power within the class, and this led to a shared understanding of practising core values within a classroom setting. 'Shared' is a key notion of decentralised control, and the core values became 'our' class values. As within a complex system, the system itself 'decides' what is and what is not acceptable. According to the conditions of a complex learning community,

the teachers/lecturers should not position themselves as the final authority on matters of appropriateness or correctness.

Structures need to be in place to enable students to participate in these decisions (Davis & Simmt, 2003), so that the system itself 'decides' what is and what is not acceptable, and understandings and insights are co-specified and shared. I believe that the condition of decentralised control applied to the introduction of the values-based approach to mathematics education classes and encouraged a positive collective response from students, whereas the imposition of a value-based approach would have yielded a negative collective response, which in turn, may have sabotaged the initiative from the beginning.

The flexibility given to students to solve problems in diverse ways was well accepted, and was an attempt to encourage the condition of decentralised control, as students' control over their own problem-solving strategies was subject to my occasional interventions, as I attempted to influence the quality of interactions amongst them. Students were regarded as the locus of learning and a fundamental part of the social action. They were required to explain their solution processes – a challenging new skill for many students who had not practised an inquiry-based methodology at school level.

The locus of control was shifted to each student in turn, as they presented their findings and explained their solution process. They appeared to enjoy the freedom of using diverse problem-solving strategies, and many accepted the challenge of explaining their thinking processes.

## 6.4. Organised randomness

The condition of organised randomness is critical to the emergence of a complex community of students (Davis and Simmt, 2003), as it helps to maintain a delicate balance between sufficient organisation to direct students' actions and sufficient randomness to allow for flexible and varied responses.

I attempted to maintain a delicate balance between sufficient organisation and sufficient randomness – to create the condition of organised randomness in the discussions around a values-based approach to mathematics education classes. As explained in Chapter Two, the students were introduced to the 'values wheel', which indicated the Faculty of Education's core values of compassion, honesty, accountability, respect and fairness. This 'values wheel' revolved around the notion of trust and was bound together by a ring of integrity.

The introduction of the 'values wheel' provided sufficient organisation to direct students' awareness of the core values, as these transcend any social barriers. Sufficient randomness encouraged student conversations around the core values, as well as their views and beliefs on whether a values-based approach to mathematics education might influence their self-efficacy.

I realised that unless students, as a collective, acknowledged, accepted and were willing to honour a class code of conduct, according to the core values described, this research study would not be possible. As the students and I worked together to develop a community of trust and integrity in our classes, I believe that students have been influenced by 'our living values'. The findings of this research study suggest an improvement in mathematics self-efficacy for all students.

With regard to improving mathematics knowledge and their belief in their ability to do mathematics, I attempted to create organised randomness in the implementation of tasks that were not 'too narrow' to invite much diversity of interpretation, or 'too open' to foster focused interpretations. By way of example, in my attempt to implement the condition of organised randomness, I gave students an assignment which required that they make a set of number cards according to the given instructions.

Students were also required to create five mathematics questions or statements for each respective number card. The constraints for students included certain assignment requirements, time constraints, necessary stationery and intermediate-phase mathematics curriculum requirements. As limiting as these conditions were, they provided opportunities for flexibility and creativity on the part of the students to develop relevant questions and design their own user-friendly number cards.

This assignment, I believe, provided a balance between sufficient organisation to direct student activities and sufficient freedom to allow for flexible and varied responses.

### 6.5. Neighbour interactions

Davis and Simmt (2003) explain that 'neighbours' in the context of a mathematics community are not "physical bodies or social groupings", but "ideas, hunches and queries" which must "bump" against one another, so as to influence each other's thinking and enable an idea to emerge which had not been previously considered by anyone in the room. They further assert that without these neighbouring interactions, the mathematics classroom cannot become a mathematics community.

What is important in the condition of neighbour interactions is not the opportunity for any direct interaction, but the possibility of making ideas collide with one another.

I attempted to create opportunities for my students to experience the condition of neighbour interactions in discussions around our core values and in many of our mathematics activities. As discussed previously, many incidents arose in the mathematics education classes. These necessitated that they discuss and debate how values, or the lack thereof, had resulted in interesting class situations.

In terms of mathematics, one activity required students within a small group to create definitions of given sets of numbers. The only conditions given for writing an appropriate definition were that it needed to be mathematically correct, suitable for intermediate-phase learners, and expressed in as few words as possible. It also needed to be made available for scrutiny by the community members of the class.

There were no conditions given for the specific length of the definition or the format in which it needed to be written. Examples of sets of numbers which students were required to define included, amongst others, square numbers, prime numbers, composite numbers and multiples. It was an interesting exercise, as members of each group in the community offered suggestions, ideas and appropriate wording, and then proceeded to debate and discuss all contributions before they attempted to modify and refine their group definitions until they were satisfied that they had created a collective and mathematically suitable definition.

Within the group discussions, students were expected to uphold the core values, such as fairness – by giving each group member a chance to contribute, respect by

accepting all contributions made, compassion by making each member feel that their contribution was valued.

According to journal and interview responses, many students enjoyed the co-operative learning strategies that were implemented in the lectures and felt that they benefitted from the group discussions. Students commented that they found the activities interesting and interactive, and, as mentioned before, they enjoyed feeling included and involved in the mathematics education classes.

They appreciated that their ideas and opinions were being listened to and valued. Students also indicated that they enjoyed challenging each other's thinking in the creation of these definitions, as well as revising and adapting their group definitions – until they felt that they had developed a mathematical definition which would relate to the given set of numbers and be meaningful to intermediate-phase learners.

As I facilitated the group discussions, I attempted to focus their thinking when necessary. I realized that the communication skills they were developing with regard to verbalising their thinking, listening to each other's contributions, refining their thinking – according to the input received from other group members and reaching the group's consensus on the most appropriate definition – was very complex and time consuming.

If consensus could not be reached within the group, the group was allowed to present two possible options. During the feedback and class discussions, consensus was generally reached as to the most appropriate and 'mathematically correct' definitions. As I moved from group to group, I was aware that the condition of neighbour interactions was influencing students' thinking process.

According to Anthony (1996), ‘active’ learning denotes learning activities in which students are given considerable autonomy and control over the direction of the learning activities. He gives problem-solving, small group work and experiential learning, as examples of active learning. The number-card activity implemented by the students, therefore, falls into Anthony’s description of ‘active’ learning activities, and it also fulfils the condition of neighbour interactions for the emergence of a complex learning community.

## 6.6 Agents of influence

My attempts to create a complex learning community of students in my mathematics education classes, gave me a clearer understanding of the agents of influence working within this learning community that nurtured students’ self-efficacy within a framework of core values that promote excellence. I believe that complex learning communities could also better inform future teachers and teacher-educator practices on what it means to be a teacher.

The data generated in this study suggest that using a values-based approach to teaching and learning has the potential to promote excellence and be an agent in effecting change in mathematics teacher-education programmes, especially where students have perceptions of their own low mathematics’ self-efficacy levels.

According to Davis and Simmt (2003), understanding the dynamics of interactions within a complex community of students enables teachers to structure their engagement with students. When structuring engagement, the notion of internal diversity suggests the need to develop activities that can be adapted by students to their particular knowledge, understandings and interpretations.

Redundancy points to the need for shared experiences and established terms of engagement. Decentralised control and organised randomness highlight the need for

careful planning in terms of prescription and the awareness of liberating constraints, while neighbour interactions focus attention on how ideas might be represented and juxtaposed. The key to creating a complex community of students within the classroom is a willingness to understand the classroom community as an adaptive, self-organizing, complex unity.

## 7. INFLUENCING STUDENTS' SENSE OF SELF-EFFICACY

As previously noted, self-efficacy is one's belief in one's own ability to perform an action with confidence. In the case of this study, this relates to students' belief in their ability to do mathematics with confidence and enjoyment. Bandura (1994) suggests that a strong sense of efficacy enhances human accomplishment and personal wellbeing. He further believes that self-efficacy may be influenced through social persuasion, where people are persuaded verbally that they possess the capabilities to master given activities to the extent that persuasive talk can lead to people exerting more effort to succeed.

Drawing on the literature which supports this theory, I realised that if I were to influence my students' self-efficacy, it was important for me to alter students' negative emotional feelings and interpretations of their own wellbeing, and create a classroom climate in which all students felt valued, and assured that I believed the best of them. Students' verbal and written responses, as well as the results indicated in Chapter Four, suggest that my continued attempts to create classroom conditions conducive to promoting student self-efficacy in mathematics education appeared to play an important role in fostering the desired results.

Both the affective-disposition statements and the pre-intervention interview schedule enabled students to reflect on their mathematics self-efficacy, their attitude

towards mathematics and the values they considered important for a lecturer to practise when interacting with students. Both the mid- and post-intervention interviews and the journal entries enabled students to reflect on what was happening in mathematics education classes and give feedback with regard to their lecturer's ability to enhance their mathematics and personal self-efficacy levels.

Student interview responses from both groups indicated that they believed that their mathematics self-efficacy levels were directly linked to their success and achievement at mathematics, or the lack thereof, during their school years. It appears, therefore, that mathematics self-efficacy is influenced by experiences of achieving success. This finding concurs with Pajares' belief (2002), as described in Chapter Two, that students who perform well in mathematics are likely to develop a strong sense of confidence in their mathematics capabilities, whereas poor performance generally weakens students' confidence in their capability.

Student descriptions and discussions of their school experiences were informative and enlightening; and they provided me with new insights and perceptions that I may not have considered in the implementation of appropriate strategies for influencing students' mathematics self-efficacy levels.

Comparison of pre-intervention and post-intervention journal and interview responses clearly suggest that both groups of students showed an increase in self-efficacy levels from the beginning to the end of the mathematics education course. In response to the question of why students felt positive about mathematics, no student in the pre-intervention interview gave credit to good teaching as a possible reason. However, during the post-intervention interview nearly half of the first-year students

and a third of the second-year students responded that 'good teaching' had contributed to their positive feelings about mathematics.

This suggests a general improvement in students' levels of self-efficacy after their engagement with the mathematics education module. Furthermore, it indicates that using a values-based approach which promotes excellence appeared to influence students' confidence levels and hence their self-efficacy levels as well.

The first formal prompt to which students responded in their journals required them to give their views and opinions regarding the benefit of a values-based approach in mathematics education classes. A student replied that "*this will only have a positive outcome if everyone upholds the values*". This student response verifies Hill's (1988) concern that even if students provisionally accept a particular value, there is no guarantee that intellectual belief will automatically imply a commitment to live by that belief.

As mentioned in Chapter Four, I responded to this comment by agreeing with the student that the ideal would be if every student took the core values seriously and was committed to practising them. However, the reality is that each person could only be held accountable for their own behaviour.

The most frequent student responses indicated that they believed that using a values-based approach to teaching and learning inspired a positive, comfortable classroom climate. Discipline, honesty, trust and respect were cited as conditions required for the creation of a "positive, comfortable" classroom climate. For many of the students, the introduction of values into mathematics education classes was an unfamiliar concept, but it appeared as if they were "*looking forward to seeing how moral values would change attitudes to mathematics in a classroom set-up*".

Comments such as these were encouraging, as it appeared to indicate that there had been a 'buy in' into the introduction of a values-based approach to teaching and learning.

Students indicated, particularly in journal responses and interview processes that the use of values had made them feel better about themselves and more positive about the subject. They indicated that this was because of the values of respect and sensitivity being 'lived out' during mathematics classes. However, there was a strong sense amongst students that these values would only be effective if they were reciprocated. Pastoll (2002) supports this view, and advocates that without reciprocal tolerance and respect, there can be no learning environment.

As mentioned earlier, Bandura (1994) suggests that successful efficacy builders should structure situations in ways that bring success and avoid placing people in situations prematurely, where they would be likely to fail often. He believes that it is important that students measure success in terms of self-improvement, rather than by triumphing over others.

In the mathematics education classes, students were given multiple opportunities to experience success, and the findings of the post-intervention affective-disposition statement indicate a 20% increase in second-year students' confidence levels in mathematics – and, as such, improved self-efficacy levels. This indicates a strong possibility that a values-based approach to teaching and learning in the mathematics education classes played a positive role in influencing students' sense of mathematics self-efficacy.

Formal prompt two required students to describe what they were enjoying/not enjoying with regard to mathematics education classes. Responses to this prompt in

student journals indicate that one in three students specifically mentioned that they were grateful that their ideas and opinions were being “listened to” and “valued” by myself and their fellow students – a condition which prompted the development of a complex learning community. The importance of enabling students to see that their contributions are valued is supported by Twigg (2010), who suggests that the inquiry process promotes self-efficacy, as students develop confidence in sharing their beliefs, ideas and experiences.

Analysis of the data for formal prompt three, in which students were asked to describe their own perceived mathematics self-efficacy – and say whether they believed it had changed since their engagement in mathematics education classes, produced interesting findings. Eighty-five percent of the participants acknowledged that their belief in their ability to do mathematics had improved, while fifteen percent of participants responded that they felt that their belief system regarding their self-efficacy levels had not changed since the beginning of their participation in the mathematics education module.

Those who believed that their self-efficacy in mathematics had not changed at all believed that their mathematics self-efficacy had been strong before the commencement of the PICM 201 course, and that they had maintained their positive attitude towards mathematics. However, no student felt that their level of mathematics self-efficacy had decreased during the semester.

Formal prompt four required the students to reflect on the problem-solving activities in which they had participated during lectures, and to describe what they enjoyed most about these activities. Students responded that they were more motivated regarding their participation in problem-solving activities since their engagement in the

mathematics education course. The most frequent reason given for this was the enjoyment and success experienced in solving problems in diverse ways. Students were also required to explain their solution process to the lecturer, class or group members and reflect on whether their chosen solution strategies needed to be refined in any way.

The skill of verbalising one's thinking was a new skill for many students and proved to be very challenging for students who had not practised an inquiry-based methodology at school level. The students enjoyed the non-threatening, collaborative problem-solving activities and believed that their experiences of success in problem solving activities had increased their confidence and their belief in their ability to do and teach 'problem-solving' strategies to learners.

The high percentage of students who experienced the 'success-breeds-success' phenomenon (Spady, 2002) made me realize the importance of providing multiple opportunities for students to experience success in order to enhance their levels of mathematics' self-efficacy. Many of the students in the mathematics education classes had not taken mathematics to Grade 12 level at school, and therefore in many cases, the student levels of confidence and competence in this subject appeared to be initially inadequate.

Pastoll (2002) emphasises the importance of assignments that lead to a practical result, as he believes it helps students to judge their own progress, and through a process of trial and error, it helps to promote confidence. It appears from student reports that the practical teaching aspect of the mathematics education assignment created important valuable learning opportunities for them.

According to the majority of student responses, it was in the implementation of this assignment with learners that students acknowledged their growth of enjoyment

levels, their confidence in their ability to do mathematics, and the confirmation that teaching appeared to be the correct career choice for them.

The data-collection instruments used consistently provided feedback that 'fear of failure' was a recurring theme with regard to students' self-efficacy. Based on student comments and findings, this fear dissipated somewhat during the intervention process, and much lower levels of 'fear of failure' were indicated by the end of the intervention process, thus suggesting that mathematics self-efficacy levels had improved.

This feedback triangulates well with the increased levels of self-efficacy suggested at the end of the intervention process. This is consistent with Bandura's comments (1994) regarding the strong correlation between a classroom climate in which students feel valued and the influence this has on promoting students' levels of self-efficacy.

The second-year group of students showed a much lower level of improvement in their mathematics self-efficacy than did the first-year group of students. It was noticeable that, particularly with the group of second-year student responses (n=51), contextual issues, such as negative school experiences, played a more dominant role than with the group of first-year students (n=79).

During the pre-intervention interview, 80% of the second-year students and 50% of the first-year students indicated a lack of confidence as the reason for negative feelings about mathematics.

It was interesting to note that although nearly half of the first-year students and 57% of the second-year students indicated in the post-intervention interview that fear of failure was still a negative factor in the development of their mathematics self-efficacy, they revealed that their fear of failure had reduced considerably. They also felt that they

were better placed to specify and overcome these fears. According to Pastoll (2002), confidence comes from success – which enhances the level of motivation in students. He asserts that even the smallest incident of confidence-building can become a turning point in a student's motivation to learn.

The increased levels of mathematics self-efficacy amongst students, therefore, suggests that the purposeful opportunities which the lecturer created for students to achieve success during the mathematics education classes contributed to these increased levels of self-efficacy.

## 8. SUMMARY

The findings in Chapter Four highlighted the implications for curriculum reform for mathematics education students, as well as the implications for the teaching and learning of mathematics. The data suggest that using a values-based approach is an appropriate strategy for mathematics education, and enabled me to reflect and develop a richer understanding of how I, as a teacher educator, could improve my practice and better meet the needs of my students.

Although I realized that some students initially saw little connection between their values and beliefs, and their engagement with the mathematics education module, there was evidence, in entries made by students in their reflective journals, as well as in the comparison of pre- and post-intervention interviews, that increasing moral reasoning was taking place.

My endeavour to live out the values which I believe create a classroom climate in which all students feel valued and appreciated, and in which there is mutual respect

and trust, has been discussed. I believe that I was able to show how I have realised the core values underpinning this research study as a living practice in my classes.

As this study was informed by notions of 'new scholarship', and was premised on the view that teaching is about engagement in participatory learning and the development of complex learning communities, I have shown how I reflected on and adapted my teaching – in an effort to direct it towards enhancing my teaching strategies, as well as my students' learning experiences.

This process of continually interrogating and reflecting on my own teaching practice, and redefining myself as a teacher educator, has informed my 'authentic' ongoing professional development (Cole & Knowles, 2000). I have embraced the knowledge, skills and values which have influenced me to change my teaching practice to an inquiry-based approach that is underpinned by constructivist principles which are consistent with the vision of teaching mathematics with passion and commitment.

I have described my attempts to encourage students to engage in the benefits and challenges of introducing values into classroom practice, to think critically, reason and solve problems. I purposely incorporated a variety of manipulative materials into my teaching to promote hands-on, minds-on, active-learning experiences. One of my realisations was that, while the students were willing to give time and energy towards this research study, reciprocity occurred when we spent time discussing the personal issues, which they had raised in journal entries, interviews and individual, group or class discussions.

Overall, the data generated in this study suggest that my students' sense of mathematics self-efficacy and their desire to strive for excellence was influenced positively. As I studied my practice of teaching, I believe that I was able to

communicate the dynamic nature of living values – and am able, in consequence, to make a claim to new knowledge. The claim is that the values-based approach to teaching has a positive influence on students' mathematics self-efficacy and their desire to strive for excellence. As such, I am committed to devoting time and energy to the task of using values to develop an innovative educational approach which would ensure that all students develop the knowledge, competencies, personal and professional values to reach their full potential, and to contribute to the teaching profession and the shaping of a fairer, equitable and more just society in the 21st century.

# CHAPTER SIX

# CONCLUSIONS AND RECOMMENDATIONS

Edmundson (2004) believes that we challenge our educational ends and teaching approaches by asking ourselves whether we can put our approaches into action – in order to live and teach better. We also need to ascertain whether these approaches are able to influence our existing educational beliefs in consequential ways that will make a difference. These challenges fuelled my desire to create opportunities for students to experience success and to pursue excellence, and to measure the effect of these opportunities that I had provided within a framework of values, inquiry tenets and a complex learning community.

My intention, therefore, was to improve my practice by implementing classroom strategies which I believed would influence the values and mathematics self-efficacy levels of my students.

As a novice teacher many decades ago, I used rote learning and memorisation as my most frequent teaching methodology. Each of the changes I have made since then has required me to make a decision to relinquish many of the traditional teaching and learning strategies with which I had become comfortable. Each decision to try different teaching strategies was a challenge for me – and initially resulted in uncomfortable experiences.

However, I began to notice changes in my classroom climate which encouraged more active learner participation and more enjoyment for both myself and my students.

Even at that stage, I was able to see that traditional teaching strategies often promote the idea that mathematics is all about a collection of mysterious and magical rules and procedures that must be memorised and practised. It also sends students the message that getting correct answers is the most important goal of their mathematics learning, and gives little attention to the processes involved in finding solutions and valuing students' ideas and problem-solving strategies.

During the course of this study, I rethought many of my assumptions and perspectives; and video-recording experiences of my practice produced a meaningful learning experience for me. The mathematics education students, as part of the research process, provided me with alternative insights for interpreting my own experiences, and enabled me to rediscover and clarify my own values.

Each shift I made in my teaching practices deepened my understanding of how to effectively create classroom climates which promote students' confidence and mathematics self-efficacy, and encourage them to reach their full potential.

The introduction of a values-based approach to mathematics education, which aimed at promoting excellence, has been a paradigm shift for me as a mathematics education lecturer. In doing so, I realised the need to move my thinking away from measuring outcomes to assessing outcomes, according to the improved learning that had taken place. In other words, I had to clearly consider what this 'improved learning' is that I wanted to take place, what values I wished to instil, and what notions of excellence I wanted to engender.

A constructivist and inquiry-based teaching and learning approach formed the framework of my understandings of how and what type of teaching and learning should take place, and provided indicators of notions of excellence.

The more deeply imbedded our assumptions, values and beliefs, the more fixed are our ideas about the way things should be done, and the more powerful they are in influencing our behaviour and our professional practice (Nieuwenhuis & Potvin, 2005). My own assumptions, values and beliefs which had been developed over many years have made me who I now am. However, it became clear that many of my, usually unexamined, assumptions were no longer true or appropriate; yet they continued to influence my behaviour and professional practice in education.

Lerman (2002) believes that it is in reflection that one recognises the conflict between what one wishes to do and what is happening in reality; and it is this that brings about change. As such, new assumptions about learning started to replace old ones, as the move from behaviouristic thinking was replaced by a more inquiry-based understanding of learning and the construction of new knowledge, skills and attitudes.

This research study has played an important role in revitalising my identity as a teacher-educator and enabled me to work more effectively in preparing future teachers. I have realised the importance of ongoing efforts to renew my own practice – benefits not only for me as a teacher-educator, but also for my students and the teaching profession.

The difficulties encountered in this research study and the episodes of dissent described in Chapter Five enabled me to interrogate my thinking and alter many of my earlier assumptions and pre-conceptions, and to develop some autobiographical accounts that began with past experiences and continue into the present. This proved a useful way for me to examine my practice and develop new orientations (Cole & Knowles, 2000).

Engaging in research on my own teaching and being reflective about my professional practice, according to the principles of the 'new scholarship' approach, has enhanced my ongoing professional development, as framed by my own experiences, perspectives, values and new beliefs. The new scholarship approach was therefore ideally suited to developing an autobiographical account of my teaching practice and the emergence of my claim to new knowledge: that a values-based approach to mathematics education teaching and learning can make a significant impact on students' mathematics self-efficacy – and encourage vitality and resilience in teacher-education programmes.

## 1. STUDENT EXPECTATIONS

Findings from this research study have shown that many pre-service teachers enter teacher-education courses with preconceptions and expectations of how they will learn to be teachers. One of these preconceptions suggested by this study is that they expect to be given insights into the practice of teaching, and not asked questions about their thinking. This preconception is fundamentally opposed to the inquiry-oriented perspective on which this mathematics-education module is based.

Pastoll (2002) believes that we will only be able to bring about meaningful change in the classroom when we have a clear picture of how learning is driven by student motivation.

Callier and Riordan (2009) ask the question whether our students select a teaching career out of a passion for the profession – or whether they have perhaps been enticed by the ready availability of teaching bursaries to further their education at a tertiary institution. I suspect that this enticement of teaching bursaries has been a reality for many of our teacher-education students who possibly would not have considered a teaching career had alternative options been available.

This possibility is reflected in what I and others have perceived as poor self-efficacy and low levels of enthusiasm. However, the data generated in this research study suggest some meaningful possibilities for improving the levels of student motivation and mathematics self-efficacy.

## 2. VALUES

Nieuwenhuis (2007) asserts that there is general agreement that values are important concerns that education institutions will have to deal with if they are serious about issues of quality and effectiveness. Haydon (2006) emphasizes that in a diverse society as in the community of mathematics education students in my classes, it is important to promote knowledge and understanding of values that are held by others within one's society. Some students in my classes come from families with progressive liberal views, while others have been brought up according to strict Muslim family traditions.

Consequently, I have made every attempt to address diverse values in my class, as opportunities have presented themselves. Haydon (2006) makes the point that understanding differences in regard to values in a plural society requires a considerable amount of knowledge – and that professionals should be committed to engaging in this debate.

The heterogeneity of students holding different values in my classes provoked much discussion; and the students and I explicitly focused on values which were important for developing a community of trust and integrity. Integrity is the product of being true to the core values of respect, fairness, accountability, honesty and compassion (shown as the ring that is both a product and binding property of the circle of trust used in this study).

It was envisaged that students would practise these core values within their educational setting and also extend it to their community living. I can vouch for the practice of values in the educational setting, but I am unable to verify to what extent this was extended to students' community living. Several incidents are described in this research study where moral courage, as explained by Kidder (2005), was practised by moving from ethical reasoning to principled action.

Kidder questions what good a conviction on values is without a willingness to put those values into action in the face of adversity. There is evidence in this research study which suggests that students have been encouraged and influenced by the positive outcomes of displays of moral courage in the face of such adversity.

I found the values-based mathematics education research study a challenging but very rewarding venture, and one that hopefully teachers and educators will be willing to adapt for their own respective educational settings. I trust that the students from the mathematics education classes will take up the challenge of using a values-based approach to teaching in their own classes – in order to influence learners' mathematics self-efficacy levels, and that they may also be inspired to model the change they hope to see in schools.

## 3. PROMOTING EXCELLENCE AND INFLUENCING SELF-ESTEEM

As described in this study, excellence may be defined as a stand that one takes that allows for performance that surpasses what was previously thought possible. As findings of this study suggest that many students entered the mathematics education classes with a particularly low sense of mathematics self-efficacy, I am encouraged that there is evidence to show that my teaching intention of creating opportunities for students to experience success, and thereby improving their academic learning and

confidence in mathematics education classes, appears to have yielded positive outcomes in that all students indicated an improved level of self-efficacy by the end of the research study.

I believe, like Pastoll, (2002) that the benchmark for excellence in teaching is a process which energises, animates and inspires learners/students, and that building good relationships, having stimulating conversations and participating in activities with students that interest them are ways of promoting excellence. As described in this study, Pajares (2002) advocates that highly regarded teachers who model excellence in their teaching can use their educational influence to encourage self-efficacy, which in turn, encourages students to strive for excellence.

My endeavour to be a role-model for 'pursuing excellence', and to inspire all students to reach their potential and to pursue excellence for themselves has produced some positive outcomes. I realize, however, that students, ultimately, must have the freedom to choose whether they would emulate my example – or withdraw from emulating the role model that I endeavoured to be.

Personal efficacy, as described by Bandura (1994), affects life choices, levels of motivation, quality in functioning, resilience to adversity, and vulnerability to stress and depression. Woolfolk (2004) claims that teachers who have a high sense of efficacy themselves and act on it – are more likely to have students who experience success and learn that effort pays off. Hess (2005) supports Woolfolk's claim and encourages teacher-educators to "construct a system that fosters excellence" (p. 192).

The term 'self-efficacy' in an educational context encapsulates the powerful self-belief that forms the framework within which teachers and students can make a difference for themselves – through confidence in their capabilities. Woolfolk (2004)

and Hoy (2004) both remind us that self-efficacy mobilises cognitive and motivational tools in the classroom situation. The findings of this research study support the notion that mathematics self-efficacy is a motivating factor for accomplishments in mathematics; and I have found no disconfirming literature regarding the basic construct relating to the importance of students' confidence in their ability to perform the task and take responsibility for their performance.

## 4. IMPACT OF DATA-COLLECTION PROCESSES

The collaborative nature of the research study enabled the students and the lecturer/researcher to each tell their stories. I used the students' affective-disposition statements, interview responses, journal entries, and video-recordings of a mathematics education lecture to make connections with students' assumptions, beliefs and opinions, utilising a mixed-method approach, as discussed in Chapter Three of this research study.

The use of affective-disposition statements appeared to be a valuable method of collecting important data – in order to quantify and qualify students' mathematics self-efficacy and motivational levels.

As noted by Cole and Knowles (2000), the use of reflective journals provides students with their own writer's voice and gives them opportunities for deeper explorations of their own beliefs, perceptions and opinions. Once my students came to trust that their journal anonymity was being honoured and their entries were valued, the journal became a tool of meaningful communication between themselves and me, as their lecturer.

As I examined student journal entries and responded to each one, I came to value that my practice was so much more than just teaching mathematics education. I view

teaching as a process of embracing the whole person who is an active participant in his or her own learning experiences. As students were given opportunities, not only to respond to the fixed prompts, but to record their highlights, frustrations or interactions, it prompted attitudes and practices of reflective inquiry as a form of professional development for me and my students.

As such, the use of journals helped me to gain access to alternative perspectives and was the key to my transformation process in moving me from the teacher I was to the teacher that I yearned to become.

The value of conducting pre-, mid- and post-intervention interviews, as was the case in this research study, to probe experiences, attitudes and perceptions of levels of self-efficacy of students was noted by Weissglass (1990), who believed that both affective opinions and more technical responses are important aspects of the data-gathering process. The interviews also served the purpose of providing students with an opportunity for reflection.

Interviews also provided the interviewer the opportunity of probing and assessing students' perceptions, attitudes and self-efficacy regarding mathematics. The verbal responses given by the students were compared with the affective-disposition statement responses and journal response findings to facilitate triangulation with regard to respondents' levels of mathematics self-efficacy.

The data generated by the student interviews were used for broad validation of the data generated by students participating in this study.

As the lecturer/researcher, I was aware of the potentially invasive nature of the interview process – as students were encouraged to give an account of their school

experiences and their engagement with the mathematics content and teaching. It was, therefore, important for the validity of this research study that an independent, unbiased, skilled professional, in the field of education, be requested to conduct the interview processes.

The interviewer attempted to create a non-threatening, relaxed atmosphere which would potentially create a trust relationship between the interviewer and the interviewees. Interviews took the form of conversational interviews, which were more than a question-answer process. This process comprised an exploration into the meaning of their experiences.

Viewing of the video-recording of a mathematics education lesson enabled me to study students' behaviours and interactions between the students and myself within an authentic lecture setting. I was able to critique my competences in engaging students in the lesson – and the extent to which I was able to live out the five core values which underpinned this research study.

## 5. MY PURSUIT OF AUTHENTIC BEHAVIOUR

According to Cole and Knowles (2000), the establishment and nurturing of meaningful, productive and mutual relationships is vital to authentic collaborative inquiry. As such, this research study engages in collaborative inquiry with pre-service mathematics education students; and it challenges the isolationist nature of teaching, by encouraging teachers to adopt attitudes and practices of collaboration.

The resulting emergence of exciting new understandings of self and students, and the transformation of my teaching practice made the complexities associated with collaborative work seem worthwhile confronting and overcoming.

This form of collaborative professional inquiry was very powerful as a tool for personal and professional development. I used the students' beliefs and opinions as frames for reflecting on my own life. Relationships were central to my research study, and I was therefore very sensitive to the ethics of research and writing procedures to safeguard the trust and dignity of the pre-service students, and the authenticity of the research study.

As such, I developed a greater understanding of the 'sacredness' of research (Denzin & Lincoln, 2003), and I believe that I built a deep relationship of trust with my students. Pastoll (2002) believes that if educators want to be taken seriously, they need to behave as authentically as possible. He asserts that it is quite acceptable at times, therefore, to be puzzled, uncertain, hesitant, gushing with enthusiasm, or whatever feels real to one.

I attempted to be as authentic as possible with my students, and to feel satisfied that, for both the students and myself, this research study contributed to a deep personal and professional understanding of how a values-based approach to teaching and learning may positively influence students' self-efficacy, and promote the pursuit of excellence.

## 6. DEVELOPMENT OF VITALITY IN TEACHING

Grossman (2008) asserts that teacher education, as a field worldwide, has been proclaimed to be in crisis, a crisis epitomized by the lack of vitality in teacher preparation. She describes how university-based teacher education is being questioned in terms of its relevance and doubted as to its contributions to student learning. Grossman (2008) believes that this crisis should be used as an opportunity for teacher-educators to strengthen their commitment to rigorous research and to work to improve teacher-education based on evidence of its outcomes.

Gatlin (2009) asserts that responding to the crisis in teacher education requires innovative thinking and a concerted effort to construct a new paradigm that encourages, rather than stifles, vitality. The new paradigm encouraged by this research study is one in which a values-base approach which promotes excellence has been used to influence and improve the current situation – where university students have been shown to have a generally poor level of mathematics self-efficacy.

Caillier and Riordan (2009) emphasize the importance of teacher-education programmes, where there is a reciprocal relationship between teacher education and school reform, insisting that if teacher education is to play a role in changing schools, it must itself change. Critics of teacher-preparation courses indicate that everyday teaching involves more complex decision-making than the one-way action of applying theory to practice (Black & Halliwell, 2000). Revitalising teacher education is best tackled as part of the effort to re-imagine and reshape teaching for the realities of education in the 21st century (Hess, 2005).

## 7. NEW SCHOLARSHIP

McNiff (2002) reminds us that action research fundamentally involves self-reflection and a commitment to improving one's practices. It can lead to the development of 'new scholarship' of one's own 'living-educational theory', and open to scrutiny one's claims to have made improvements in practice. This study was, therefore, informed by notions of 'new scholarship'. This is premised on the view that teaching is about engagement in participatory learning and the development of communities of creative scholars.

After completion of this research study my extant educational theory is that a values-based approach may be regarded as an effective approach by mathematics

teachers and mathematics teacher-educators for the purposes of pursuing excellence and influencing students' levels of mathematics self-efficacy.

## 8. RECOMMENDATIONS

The findings of this limited research study pose the question: "Is this approach replicable on a large scale?" In order for this question to be answered, a recommendation is that the practice be replicated within a research design that includes the use of standardized self-efficacy instruments and large-scale statistical treatments to interrogate changes in self-efficacy. The Science Teacher Efficacy Beliefs Inventory (STEBI) developed by Riggs and Enochs (1990) is one such instrument, and standard inferential statistics, such as the Analysis of Variance (ANOVA) and the Analysis of Co-Variance should provide revealing evidence in terms of shifts in self-efficacy in much larger samples.

More in-depth interrogation of students' conceptions of the role of values, and notions of excellence in mathematics education would also probably be profitable in the search for greater understanding of these factors.

Notwithstanding the recommendations made above, this research study has a contribution to make in terms of informing teacher educators, teachers and policy-makers about perspectives and interventions which may contribute to pre-service teachers' mathematics self-efficacy levels. It suggests strategies to develop teachers who are able to contribute to the integrity and vitality of the teaching profession. These strategies include the role that a values-based approach to the teaching and learning of mathematics may have on influencing students' self-efficacy levels, both mathematically and within other subjects.

The findings of this study suggest, with a fair degree of confidence, that opportunities could be created for learners/students to experience success and pursue excellence within a framework of values and inquiry tenets, and that the values-based approach may enable them to strive towards their full potential and improve their levels of self-efficacy.

Possibilities have also emerged for teachers/teacher-educators to identify revitalization techniques, as they rethink their assumptions and perspectives in practice; and, as opportunities for the effective use of a 'new scholarship' approach in reflective research on professional practice become more widespread. The creation of conditions for the emergence of a complex community of students which enables teachers/teacher educators to structure their engagement with students appears to be a key aspect for the development of a classroom climate which fosters enjoyment, opportunities for experiencing success and promoting confidence and improved levels of mathematics self-efficacy.

There exists an urgent need to challenge the isolationist nature of teaching through the adoption of attitudes and practices via exciting new understandings of teaching practices. Such understandings may include the use of reflective journals which could provide opportunities for learners/students to have their own voice through writing. The encouragement of innovative thinking towards a new paradigm that promotes, rather than stifles, vitality and helps reshape teaching for the realities of 21st century education is an issue worthy of serious consideration.

In attempting to promote such a paradigm shift, it is important that policy-makers, education departmental officials and teacher educators take cognisance of the reality that students consistently refer to, viz. the quality of their own teachers as the primary reason for their achievements and choice of careers.

I believe that the findings of this research study have the potential to challenge teacher educators to re-assess, adapt and improve their teaching strategies, where necessary, and revise the assumptions about teaching and learning on which they are based. Black and Halliwell (2000) point out that the critics of teacher-preparation courses indicate that everyday teaching involves more complex decision-making than the one-way action of applying theory to practice.

Garmston (2005) believes that as evidence mounts that student learning is the result of collaborative effort, teachers will increasingly need skills to improve instruction, raise student achievement and enhance their professional community. This research study suggests that if our professional community of teachers and teacher-educators aims to raise student achievement by raising students' levels of confidence, and, as such, influence their self-efficacy, then a values-based approach to teacher education should be a serious consideration when seeking contributions to the transformation of existing teacher-education programmes.

## 9. CONCLUDING REMARKS

Students in this study often referred to the quality of their teachers as the primary reason for their achievements, or the lack thereof, and for the choice of their career. As such, the findings of this study yield conclusive evidence of student responses in which they cited that "good teaching" contributed to their positive feelings about mathematics; and hence, their self-efficacy levels as well.

As I critiqued the literature that informed my practice and produced evidence to support my transforming practice, I believe I was able to test Woolfolk's recommendation (2004) of setting high goals for my students and constructing a system

that fosters excellence. In the process, I experienced many of the outcomes he describes as being typical of students who are more likely to experience success.

Working in collaboration with students regarding the interrogation of my own practice and study, was a new experience for me. I have always valued the opinions of others, but I felt hesitant about giving my students the responsibility for holding me accountable for living out the values identified in this research study. However, I realized the importance of giving them a voice in finding meaningful ways of improving my teaching practice which would motivate their own mathematics self-efficacy levels, and promote excellence in their engagement in mathematics education.

The evidence described in this research study suggests that a values-based approach to teaching and learning, aimed at promoting excellence, is able to influence students' levels of mathematics self-efficacy. Personally, the significance of this research study is in relation to how I have learned to live my values more fully in my own practice. I have developed greater insights into the issues I was investigating and how my work has the potential to influence my students in new ways.

Considering the current crisis in mathematics and science education in South Africa, as well as the crisis in responsible citizenship, it is imperative that we seriously consider the devastating consequences of teacher-education programmes which are not underpinned by sound value systems and effective approaches to teaching and learning. The challenge is to implement a curriculum which is relevant in content and context to South African educational demands for a strategic, but often controversial, reform process.

An underlying, but implicit intention of this study was to influence stakeholders at policy and other levels to consider and embrace the possibilities that a values-based

approach to mathematics education may have on students' levels of mathematics self-efficacy, and to include these notions in the design of mathematics curricula for the 21st century.

I believe that the findings of this study can contribute to the ongoing debate about the process of quality teaching and learning in terms of the possible gains which could emerge from a values-based approach to teacher education. The data suggest that, in spite of large classes of multi-cultural and diverse students with differing world views, I was able to encourage my students to commit themselves to devoting time and energy to the task of using values to develop an innovative educational approach with the potential to promote the development of students' knowledge, competencies, and personal and professional values as they strive to reach their full potential and help shape a fairer, equitable and more just society in the 21st century (Department of Education, 2002; 2007).

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# APPENDICES

## APPENDIX A

### Affective-Disposition Statements

Pre-intervention affective-disposition statement

| Year: | 1 | 2 |
|---|---|---|
| B Ed (IP) Course: | Mathematics | Language |

| | Strongly Agree | Agree | Uncertain | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| I am looking forward to participating in the mathematics education classes this semester | | | | | |

Post-intervention affective-disposition statement

| Year: | 1 | 2 |
|---|---|---|
| B Ed (IP) Course: | Mathematics | Language |

| | Strongly Agree | Agree | Uncertain | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| I enjoyed participating in the mathematics education classes this semester | | | | | |

## APPENDIX B

### Pre-intervention Interview Schedule

| | | |
|---|---|---|
| Name of interviewee: | | |
| Student is in year: | 1 | 2 |
| B Ed (IP) Course: | Mathematics | Language |
| Date: | | |

Note: 1 being low and 10 being high

| 1. | On a scale of 1-10, how do you feel when you do mathematics? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

| 2. | What do you think some reasons could be for feeling this way about mathematics? |
|---|---|
| | |

| 3. | On a scale of 1-10, how good do you think you are at mathematics? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

| 4. | What do you like most about doing mathematics? |
|---|---|
| | |

| 5. | What don't you like about mathematics? |
|---|---|
| | |

| 6. | What do you do when you don't understand something in mathematics? |
|---|---|
| | |

| 7. | What values do you think are important for a lecturer to model when teaching mathematics? Explain your answer. |
|---|---|
| | |

## APPENDIX C

### Mid- and Post-intervention Interview Schedules

The following five questions were included in the Pre-intervention Interview Schedule for the purposes of both mid- and post-intervention interviews.

| 8. | Do you think that your lecturer is living any of the following values in her classes? If so explain how. | |
|---|---|---|
| | *Respect* | |
| | *Fairness* | |
| | *Accountability* | |
| | *Honesty* | |
| | *Compassion* | |

| 9. | Have you any comments about the idea of including a focus on values when teaching mathematics? |
|---|---|
| | |

| 10. | Has your lecturer helped you in any way to develop a sense of trust in her? Explain your answer. |
|---|---|
| | |

| 11. | Do you think that your lecturer has portrayed a notion of excellence in her teaching? Explain your answer. |
|---|---|
| | |

| 12. | How do you feel about mathematics since the start of module PICM 201? Explain your answer. |
|---|---|
| | |

## APPENDIX D

CD attached to the inside back cover of the research study.

- **Video Representation: Mathematics-Education Lesson**

Please see CD for a video representation of a mathematics education lesson presented by the researcher/lecturer of mathematics education module PICM201.

- **Excerpts from Students' Journals**

Please see CD for excerpts from student journals:

- 8 student responses for each of the five formal prompts
- 8 informal journal entries by participating students