

THE BELIEFS OF PRESERVICE TEACHERS ABOUT  
MATHEMATICS TEACHING AND LEARNING

SALLY DIANE HOBDEN

A Dissertation submitted to the Faculty of Community and Development Disciplines  
of  
University of Natal  
in partial fulfillment of the requirements for the degree of  
Master of Education (Tertiary Education)  
December 1999

## ABSTRACT

**The beliefs of preservice teachers about Mathematics teaching and learning**

Preservice teachers have had a twelve year “apprenticeship of observation” in the practice of teaching and as a consequence have internalised a set of beliefs about Mathematics teaching and learning. These beliefs are usually implicit but nevertheless influence the teaching practice of the preservice teachers to the extent that they “teach as they were taught.” A preservice Mathematics Education course, falling as it does between the prospective teachers’ experiences as scholars, and their future teaching experience provides an ideal opportunity for preservice teachers to review their personal beliefs prior to carrying them over to teaching practice. In order to facilitate this review, a series of activities was designed as part of a Mathematics Education course for preservice secondary phase Mathematics teachers. These activities provided opportunities for student teachers to examine their beliefs, to discuss and write about these beliefs, to read about the beliefs of others, and finally to decide whether they wished to retain or modify their personal beliefs.

Data on the personal theories of the preservice teachers was obtained from the written responses to various critical incidents, from metaphors for the teaching and learning of Mathematics drawn and described by the preservice teachers, and from interviews with selected participants. These theories were classified into qualitatively different categories. After completing several developmental activities and a five week period of classroom teaching, the preservice teachers were invited to reconsider their personal theories and amend their metaphors. This provided evidence of reflection and development in their thinking.

It is contended that the personal theories of preservice teachers are not only reflected in their classroom practice but also function as barriers to impede acceptance of novel ideas and innovations. The findings of this study contribute to the understanding of the thinking of preservice teachers and inform the development of a curriculum for the Mathematics Education component of a Professional Studies course.

## PREFACE

The research described in this dissertation was carried out at Edgewood College of Education from January 1998 to December 1999, under the supervision of John Boughey of University of Zululand and Ruth Searle of University of Natal, Durban.

These studies represent original work by the author and have not been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

*Shobden*

S D HOBDEN

Student number 971168523

DURBAN

December 1999.

## ACKNOWLEDGEMENTS

Firstly, I would like to acknowledge the academic support and friendship of the 1997 group of students for this initial Master of Education (Tertiary Education) programme. The diversity of experience of the group members broadened my perspective on Education and challenged many of my long held opinions. Special thanks go to Ruth Searle and John Boughey for their role as facilitators of the programme and for the help with this dissertation.

I would like to record my appreciation to the students at Edgewood College of Education for their willingness to allow their work to form part of this study, and to Linda van Laren and Thelma Rosenberg, my colleagues in the Mathematics department, for their supportive interest in my research.

Finally, I must thank my family and friends for their support during the course of this study, especially my husband, Paul, for his patient help in so many aspects of this study.

## TABLE OF CONTENTS

<b>CHAPTER 1</b>	<b>INTRODUCTION AND OVERVIEW.....</b>	<b>1</b>
1.1	Motivation for the Study.....	1
1.1.1	Personal Experience and Interest.....	2
1.1.2	Current Reforms in Teacher Education .....	3
1.1.3	The Influence of Personal Beliefs and Theories .....	6
1.2	Research Questions and Focus of Inquiry .....	7
1.3	Definition of terms .....	9
1.4	Significance of the study .....	10
<b>CHAPTER 2</b>	<b>CONCEPTUAL FRAMEWORK.....</b>	<b>12</b>
2.1	Introduction .....	12
2.2	Components of a Mathematics Education Programme.....	12
2.3	Beliefs about Teaching and Learning .....	15
2.3.1	Beliefs.....	16
2.3.2	Conceptions about Teaching and Learning.....	17
2.3.3	Conceptions about Mathematics .....	23
2.3.4	Conceptions about Mathematics Teaching and Learning.....	24
2.4	Eliciting personal theories.....	25
2.4.1	Metaphors as a means of eliciting personal theories .....	26
2.5	Personal theories – do they matter in the classroom? .....	29
2.6	Changing and adapting personal theories.....	31
2.7	Summary.....	34
<b>CHAPTER 3</b>	<b>RESEARCH METHODOLOGY.....</b>	<b>36</b>
3.1	Choice of methodology.....	36
3.1.1	History of qualitative research .....	36
3.1.2	The suitability of a qualitative approach to this study .....	37
3.1.3	Phenomenography.....	39
3.2	Participants in the study .....	39
3.3	Instrumentation.....	42

3.3.1	What is the perceived role of personal theories in the professional development of preservice Mathematics teachers? .....	43
3.3.2	What personal beliefs about the teaching and learning of Mathematics do preservice Mathematics teachers hold? .....	45
3.3.3	Are Preservice teachers aware of the links between their personal theories and their classroom practice?.....	49
3.3.4	Do preservice teachers view their personal theories as developing or complete?.....	52
3.4	Procedures for the Collection of Empirical Material .....	52
3.4.1	Sequencing of Activities.....	52
3.4.2	Ethical Considerations .....	53
<b>CHAPTER 4 ANALYSIS AND RESULTS .....</b>		<b>55</b>
4.1	We Need Proper Maths Education - Not Art!.....	55
4.2	- “...and at the end of it, Knowledge is Transferred to the Student” .....	61
4.2.1	Activity Two - What would you do in this situation? .....	62
4.2.2	Activity Three – Metaphors for the teaching and learning of Mathematics .....	68
4.2.3	General observations about the personal theories of preservice Mathematics teachers .....	74
4.3	Implicit Theories Have Consequences .....	76
4.3.1	Reading Activity - Personal Conceptions of Teaching and Learning.....	76
4.3.2	Teaching Activity - Practical Teaching based on Particular Conceptions of Teaching and Learning .....	77
4.4	Changing a Personal Theory .....	78
4.4.1	General remarks.....	78
4.4.2	Nature of learners as an impetus to change.....	79
4.4.3	Examples of Changes in Metaphors .....	82
4.5	Summary of Results .....	86
<b>CHAPTER 5 DISCUSSION.....</b>		<b>87</b>
5.1	What is the perceived role of personal theories in the professional development of preservice Mathematics teachers? .....	87
5.2	What personal beliefs about the teaching and learning of Mathematics do preservice Mathematics teachers hold? .....	89
5.2.1	“Teaching by telling” .....	89
5.2.2	Practice makes Perfect.....	91
5.2.3	Validity of the empirical material.....	91

5.3	Are Preservice teachers aware of the links between their personal theories and their classroom practice?.....	92
5.3.1	Theorising Practice or Practising Theory.....	92
5.3.2	Teaching Mathematics above teaching children .....	93
5.4	Do preservice teachers view their personal theories as developing or complete?.....	94
5.5	The Way Forward .....	95
<b>REFERENCES.....</b>		<b>97</b>
<b>APPENDIX A</b>	<b>Activity One: Outcomes of a Mathematics Education Course.....</b>	<b>100</b>
<b>APPENDIX B</b>	<b>Activity Two : What Would You Do in this Situation?.....</b>	<b>103</b>
<b>APPENDIX C</b>	<b>Activity Three: Metaphors for the Teaching and Learning of Mathematics.....</b>	<b>108</b>
<b>APPENDIX D</b>	<b>Interviews with Focus Students.....</b>	<b>111</b>
<b>APPENDIX E</b>	<b>Reading Activity: Personal Conceptions of Teaching and Learning.....</b>	<b>112</b>
<b>APPENDIX F</b>	<b>Practical Teaching Based on Particular Conceptions of Teaching and Learning .....</b>	<b>115</b>
<b>APPENDIX G</b>	<b>Metaphors for Teaching and Learning Mathematics (a second look).....</b>	<b>117</b>
<b>APPENDIX H</b>	<b>Letter Requesting Permission to Use Preservice Teachers' Work for this Study .....</b>	<b>120</b>
<b>APPENDIX I</b>	<b>Table of Criteria for the Classification of Personal Theories.....</b>	<b>121</b>

## LIST OF TABLES

Table 1 Students included in the sample.....	41
Table 2 Overview of the data collection methods.....	43
Table 3 Time scale for data collection.....	55
Table 4 Criteria for the classification of outcomes for a Mathematics Education course .....	56
Table 5 Desired Outcomes of a Mathematics Education Course.....	57
Table 6 Responses to Jane’s Story.....	62
Table 7 Indicators to theories-in-use for Richie's story.....	65
Table 8 Indicators to theories-in-use for Ms Jones' story.....	67
Table 9 Classification of Metaphors suggested by Second Year Students.....	75
Table 10 Classification of Metaphors suggested by Third Year Students.....	75
Table 11 Classification of Metaphors suggested by Fourth Year Students.....	75
Table 12 Number of Preservice Teachers who amended their initial metaphors for the teaching and learning of Mathematics.....	79



## LIST OF FIGURES

Figure 1 Sequence of Activities .....	53
Figure 2 Graphical representation of the distribution of outcomes for a Mathematics Education course suggested by preservice teachers in the second year of study. ....	57
Figure 3 Graphical representation of the distribution of outcomes for a Mathematics Education course suggested by preservice teachers in the third year of study. ....	57
Figure 4 Graphical representation of the distribution of outcomes for a Mathematics Education course suggested by preservice teachers in the fourth year of study. ....	58
Figure 5 Steve’s Vision of the Way Things Ought to Be. ....	70
Figure 6 Sipho’s Vision of the Way Things Ought to Be.....	71
Figure 7 Myron’s Vision of the Way Things Ought to Be. ....	72
Figure 8 Marc’s Vision of the Way Things Ought to Be.....	73
Figure 9 Sameer’s Original and Reconsidered Metaphors for the teaching and learning of Mathematics .....	80
Figure 10 Vusi’s Original and Reconsidered Metaphors for the teaching and learning of Mathematics .....	81
Figure 11 Myron’s Vision of the Way Things Could Be - Reconsidered Version.....	82
Figure 12 Marc’s Vision of the Way things Could Be - Reconsidered Version .....	83
Figure 13 Sandiles’s Vision of the Way Things Ought to Be .....	84
Figure 14 Steves’s Vision of the Way Things Ought to Be - Reconsidered Version.....	85

## CHAPTER 1

### INTRODUCTION AND OVERVIEW

This study is an investigation into the beliefs about Mathematics teaching and learning held by preservice teachers. The participants in the study were students at Edgewood College of Education in KwaZulu Natal, South Africa. These students were studying towards a Higher Diploma in Education (Secondary Education) which was, at the time, a four year full time course. All the second, third and fourth year Mathematics Major students undertook the activities on which the investigation was based, as part of the Mathematics Education course which I facilitated. These activities were designed both to elicit data on the students' thinking and beliefs, and to assist the students to make their implicit beliefs explicit and open to scrutiny.

This chapter provides an overview of the study. The motivation for undertaking this research is discussed and the research questions and key terms are introduced. In conclusion, the significance of the results of this study in the current educational milieu in South Africa is suggested.

#### 1.1 MOTIVATION FOR THE STUDY

The motivational factors for undertaking this research project were threefold. Firstly, personal experience had led to an interest in the thinking and personal theories of preservice teachers, secondly, current reform initiatives were calling for reflective practice, and thirdly, personal beliefs and theories appear to be a neglected area in teacher education programmes despite their significant impact on teacher behaviour. These three factors are discussed in more detail in the ensuing sections.

The nature of the current reform initiatives in both teacher education and the professional work of teachers will be discussed in this section. The significance of the personal theories of teachers is highlighted, leading to a consideration of the implications for professional Mathematics Education courses.

### 1.1.1 Personal Experience and Interest

This study was motivated in part by an interest in the observed conservatism displayed by preservice teachers introduced to new ideas in the Mathematics Education component of their Professional Studies course. Despite their stated discontent with their own schooling, there seems to be a strong resistance to anything different. This lack of enthusiasm for innovation and change is problematic in a context in which a new curriculum based on an alternative paradigm for teaching and learning is being introduced.

There seems to be a strong conviction among preservice teachers that the way in which they were taught should provide a model for their own teaching. A good example arises from a discussion of long division. Typically many hours of instructional time in the primary school are spent in acquiring mastery of this complex algorithm. Despite this, many student teachers are not confident of their ability to perform the procedure and readily admit that they would use a calculator to get the answer, and have in fact done so ever since they reached secondary school. Nevertheless, the same student teachers are horrified at my suggestion that perhaps learning to do long division with large numbers is a waste of Mathematics learning time when calculators are so readily available. They seem to firmly believe that if they had to master the algorithm, so should future generations of scholars. What is the thinking behind this?

I have been disappointed over the years at the lack of enthusiasm shown towards models of instruction different from the “teacher tell” type of lesson. Group work, investigations and self study projects are dismissed as fanciful and time wasting. I began to understand some of this conservatism when I became interested in peoples’ conceptions of learning during the coursework component of my Masters studies. When preservice teachers suggested metaphors for teaching and learning Mathematics, it became clear that some believed the teacher to be the sole transmitter of knowledge. I realised that such a belief could provide a barrier to facilitating opportunities for pupils to learn independently. I became interested in the notion that particular beliefs about teaching and learning Mathematics constrain the teachers’ choice of classroom activities.

I became interested in researching the personal beliefs of preservice teachers, and seeking ways to assist preservice teachers to become reflective about their own beliefs and the links to their classroom practice.

### 1.1.2 Current Reforms in Teacher Education

The government of the day is calling for reform in education at all levels including teacher education. The role of educators is being redefined to include a wider range of competences than previously. This investigation into the personal beliefs of preservice teachers is a response to the more reflective role required of educators.

Teacher education in South Africa is currently undergoing radical change. Rationalisation and economic constraints have forced the closure of many Colleges of Education throughout the country, and the introduction of new norms and standards has brought change to those remaining. At the time of writing, the current national government document is the Norms and Standards for Educators which is a publication of the Technical Committee On the Revision of Norms and Standards for Educators (September 1998). This document lists nine perceived weaknesses in teacher education (pp. 6-7), the following one being of particular interest for this study:

Curricula that - in both form and content - are characterised by outdated and autocratic concepts, philosophies, and methodologies, that do not develop teachers' ability to think critically and problem solve; and draw a hard divide between theory and practice. (Technical Committee On the Revision of Norms and Standards for Educators, 1998, p.7).

The particular weaknesses identified here are the ability to think critically, and the existence of the hard divide between theory and practice. The latter criticism was probably aimed at the mismatch often observed between the material presented in College lectures and the realities of the classroom. However, it does seem to highlight a conception which I would contest, that it is possible to separate educational theories from classroom practice. I regard educational theories, either formal academic theories or more importantly informal personal theories, as prime motivating influences on classroom practice.

The primary function of a Teacher Education programme is to provide the teaching profession with suitably educated and trained members. Careful note must be taken of the statutory requirements for teachers to ensure that the graduating teachers are able to fulfil the roles expected of them. Recently defined roles for educators in South Africa are described in this section.

### *Newly Defined Statutory Roles for Educators*

Six roles for educators are suggested by the Technical Committee On the Revision of Norms and Standards for Educators (September 1998). These are

1. Learning mediator
2. Interpreter and designer of learning programmes and materials
3. Leader, administrator and manager
4. Scholar, researcher and lifelong learner
5. Community, citizenship and pastoral role
6. Learning area/subject/discipline/phase specialist

The fourth of these roles is pertinent to this study. The document elaborates on this role as follows:

The teacher will achieve ongoing personal, academic, occupational and professional growth through pursuing reflective study and research in their learning area, in broader professional and educational matters, and in other related fields. (Technical Committee On the Revision of Norms and Standards for Educators, 1998, p.54).

This description of the role clearly indicates that the teachers should be reflective persons, continually thinking about their practice, and seeking ways to improve. An important foundation for reflectiveness is an awareness of the personal beliefs that prompt particular practices. Consequently Teacher Education programmes should provide opportunities for preservice teachers to investigate their personal theories of teaching and learning.

### *New requirements for initial teacher education qualifications*

The document mentioned above sets out competences related to each of the six roles. These competences are categorised as:

- Practical competences; the demonstrated ability, in an authentic context, to consider a range of possibilities for action, make considered decisions about which possibility to follow, and to perform the chosen action
- Foundational competences; where the learner demonstrates an understanding of the knowledge and thinking which underpins the actions taken
- Reflexive competences; in which the learner demonstrates ability to integrate or connect performances and decision making with understanding and with the ability to adapt to change and unforeseen circumstances and explain the reasons behind these actions.

The competences listed under the role as learning area/subject/discipline specialist have particular relevance to a Mathematics Education course that is a professional development

course for prospective Mathematics teachers. Foundational competences for initial teacher education include understanding the ways of thinking and doing involved in a particular subject, and understanding the assumptions underlying the descriptions of competence in a particular subject. The reflexive competences include reflection on own practice, identifying and critically evaluating what counts as undisputed knowledge, necessary skills, and important values.

### *Reform of Preservice Mathematics Education Courses*

The new requirements for initial teacher education discussed above, clearly call for a professional development programme that goes beyond “tips for teachers”. The need to construct a programme in line with current reform initiatives in Teacher Education provided an impetus for this study. The recurring idea of teacher reflectiveness evident in the report of the Technical Committee On the Revision of Norms and Standards for Educators (September 1998) supports the consideration of the personal beliefs of preservice teachers.

Researchers in the field of Mathematics Teacher Education have noted with concern that the preservice courses offered across a range of Colleges "constitute a relatively weak intervention" (Hill, 1997) and can be described as a "low impact enterprise" (Zeichener & Grant, 1981). By this is understood that the beliefs and attitudes held by students entering such programmes are little altered by the end of the programme. This is disturbing since most student teachers enter the course with the view that Mathematics is a set of rules that can be taught instrumentally (Hill, 1997) and with simple theories of teaching (Fox, 1983). Most teacher educators would hope that the students would leave with a greater understanding of the complex nature of learning, more developed theories of teaching and a wider view of the task of Mathematics teaching. The challenge is to design a curriculum that will facilitate such a change.

No designer of a preservice teacher education course can afford to disregard the impact that the beliefs of the students have on the effectiveness of the course. It would however, be unwise to begin on an assumption of deficit and to take the simplistic position that the preservice teachers' implicit theories are universally shallow, inadequate and in need of change. However it is probably safe to assume that preservice teachers' personal theories are incomplete, and

largely unconscious. I agree with Clark (1992) that beliefs and theories that remain unconscious and implicit will neither grow nor become elaborated.

In an effort to improve the effectiveness of the Mathematics Education component of the teacher education programme, this study seeks to identify and classify the personal theories of Mathematics preservice teachers, and to raise the students' awareness both of the existence and quality of their own theories, and the consequences of these theories.

Further influences of personal beliefs are discussed in the following section.

### **1.1.3 The Influence of Personal Beliefs and Theories**

The central focus of this study is the beliefs held by preservice teachers regarding the teaching and learning of Mathematics. A distinction is made between the personal theory of a person which is probably an aggregate of experiences, other people's ideas, wishful thinking and personal opinion, and the formal, published and well articulated theories of educationists. Does it matter what a young, inexperienced preservice teacher thinks about the teaching and learning of Mathematics?

Clark (1992) supports the idea that personal theories do indeed matter.

Teachers' implicit theories are more than private matters of personal taste and opinion. They can have dramatic consequences.....Implicit theories can make a difference. Implicit theories have consequences. (Clark, 1992, pp. 78-79)

Two significant consequences are discussed below.

#### *Implicit personal theories as barriers against new ideas*

All that happens in the preservice course, all the ideas presented and discussed, are passed through a "filter" of the students' personal beliefs. Only that which passes through is given attention, the rest is consciously or unconsciously dismissed. As Clark (1992) remarks, "our attention is selective: we cannot attend to everything. And our beliefs and theories define what is foreground and what is background; what to attend to and what to ignore" (p78). Mahlios and Maxson (1995) suggest that the mismatch between the implicit views held by the students entering preservice teacher education courses and the views embedded in the course may be at least partly responsible for the failure of some students to learn course concepts and to adopt the faculty approach to teaching and learning. It is easy to envisage that a simple transfer view

of learning will provide an obstacle to acceptance of constructivist learning in which the learners build their knowledge from the inside. In order to reduce the negative effects of this mismatch, Mahlios and Maxson (1995) suggest surfacing the beliefs of entering students and discussing these with students in the light of new ideas. This view is supported in the introduction to a learning guide designed to assist teachers to understand outcomes-based education where it is written that for teachers “to be able to “hear” and understand the implications of a democratic order, a course that is focussed on getting teachers to think about their values and profession seemed utterly essential”(Lubisi, Wedekind & Parker, 1997, p vii).

### *Personal theories as a significant influence on classroom practice*

The personal beliefs of preservice teachers (or in-service teachers) about the teaching and learning of Mathematics exerts a powerful influence on their classroom practice. This is well expressed by Manouchehri (1997) who reports that "research consistently shows that teachers translate their knowledge of Mathematics and pedagogy into practice through the filter of their beliefs." Pajares (1992) suggests that "unexplored entering beliefs may be responsible for the perpetuation of antiquated and ineffectual teaching practices" (p.328). I suspect that this underlies the folk wisdom that tells us that “teachers teach as they were taught.” Part of the role of a preservice Mathematics Education course is to break this cycle and the design of such courses must include opportunities to explore implicit personal beliefs.

## **1.2 RESEARCH QUESTIONS AND FOCUS OF INQUIRY**

The preservice Mathematics teachers study Mathematics as an academic major subject, and their professional development occurs within a course that I like to call Mathematics Education, but which has been commonly known as Methodology. Historically these methodology courses have been seen as “soft” courses, non-examinable, and merely a source of teaching tips. My vision for the course went far beyond this. As a first step, I sought to ascertain what expectations the students had of a Mathematics Education course, and in particular if they saw a place for examining formal theories of teaching and learning Mathematics and their own thinking. This led to the first research question:

*What is the perceived role of personal theories in the professional development of preservice Mathematics teachers?*

A prime focus of this study was to investigate the particular personal theories of the students at the beginning of the course. I considered it important to provide opportunities for the students



to think about Mathematics teaching and learning and to try to articulate a personal theory. While this was important for their own professional development it also generated data about the personal theories initially held by the preservice teachers which was used to inform the second research question:

*What personal theories about the teaching and learning of Mathematics do preservice Mathematics teachers hold?*

The link between personal theories and actual classroom practice has been raised as a motivating factor for this study. I consider an awareness of this link an important component of self-knowledge that in turn is necessary for personal professional development. In order to promote this awareness, I designed a number of developmental activities. However, the only authentic opportunity to answer the third research question was while observing the preservice teachers during the Teaching Practice period.

*Are preservice Mathematics teachers aware of the links between their personal theories and their classroom practice?*

I hoped that the activities of the Mathematics Education course and the experiences of five weeks teaching in a school would lead to some personal growth and development for the students. At the very least, they might be exposed to alternative viewpoints and develop a notion that things could be different. Perhaps my main purpose was to promote openness to change and development. By giving the participants in the study an opportunity at the end of the course to review their initial theories, I was able to obtain data to answer the final research question:

*Do preservice Mathematics teachers view their personal theories as developing or complete?*

The investigations implied by the research questions are related to ideas and beliefs held by a group of about fifty preservice teachers. This study sought to describe and classify their personal theories and so a qualitative approach was deemed appropriate. Quantitative analysis was used to describe the distribution of classes of ideas throughout the groups and for means of comparison between the different year groups. The analysis was largely phenomenographic, seeking to reveal the qualitatively different personal theories of the participants in the study, and to classify these theories, rather than the participants themselves.

### 1.3 DEFINITION OF TERMS

Several terms and constructs are used throughout the chapters that follow and the purpose of this section is to provide brief working definitions and descriptions that will assist a common understanding. Most of these ideas are discussed in greater detail as part of the conceptual framework of this thesis.

Preservice teachers: This term is used to describe teachers in training. In the context of this study, preservice Mathematics teachers are students at a College of Education and are sometimes referred to as students. Their teaching experience is limited to five weeks per year when they undertake what is known as Teaching Practice. I have usually chosen to use the term “preservice teacher” in preference to “student”, since it serves to emphasize the professional nature and direction of Teacher Education. The interval in which a person is a preservice teacher is short in comparison to the time spent as a scholar and the time ahead as a professional teacher. It is however, a critical time in professional development and a window of opportunity for reflection and change. Much of the literature to which I refer deals with the thinking and practice of teachers, which has obvious implications for prospective teachers.

Formal theory: In this study, formal theories refer to well-documented and published sets of ideas put forward by educationists. Examples would be Skemp’s theory of relational and instrumental understanding in Mathematics (Skemp, 1978) or Van Hiele’s theory of the development of geometric thinking (van Hiele, 1986). A feature of formal theories is their coherence and the quality of their expression. In addition, most of the formal theories have been subject to comment from the academic community and have gained status by publication. These large scale general theories have usually been based on a “systematic view extrapolated from a much wider range of events and situations than any one individual can have experienced and contemplated” (Orton, 1987). Preservice teachers are normally required to study such theories and their implications for classroom teaching.

Personal theory: This study focuses on personal theories of teaching and learning Mathematics. In contrast to the formal theory discussed above, a personal theory is an individual’s own set of ideas used to explain or make sense of something. It is unlikely that a person could articulate a well reasoned and coherent theory without a good deal of reflection. A personal belief forms part of a personal theory along with values, understandings,

assumptions – the ways of thinking about the teaching profession (Tann, 1993). When a teacher takes sides on an issue, such as using a calculator in Mathematics tests, it could be said that a theoretical position has been adopted (Orton, 1987). Past experience, reading, discussions and personal life view would all contribute to a personal theory that could possibly comprise an inconsistent set of beliefs. The implicit theories referred to by Clark (1992), are personal theories that have not been surfaced. From a study of university lecturers, Fox (1983) suggested that personal theories of teaching could be broadly classified into simple and developed theories. Simple theories of teaching are those in which the teacher is the source and shaper of the commodity of learning, whereas developed theories describe the teachers and learners as partners in the learning process.

Metaphor : A metaphor is an imaginative way of describing a particular situation by using another seemingly unrelated situation that has some of the qualities and characteristics of the situation being described. Of interest in this study was the creation of metaphors for the teaching and learning of Mathematics. The preservice teachers sought to draw and describe situations that they considered to have some of the essential features of Mathematics teaching and learning. The metaphors chosen provided insights into the thinking of the participants. For example, I see a significant difference in the thinking of a preservice teacher who describes the Mathematics teaching and learning experience as rain falling on plants, and the thinking of one who describes it as coaching a soccer team. I also consider metaphors to be a good prompt to encourage preservice teachers to reflect on their own personal theories. These metaphors were used as a source of data to classify the personal theories of the preservice teachers.

#### **1.4 SIGNIFICANCE OF THE STUDY**

Insight into the thinking and implicit theories of preservice teachers is invaluable to those who seek to facilitate the professional development of teachers in training. The fact that these prospective teachers are young and inexperienced does not preclude them from having strong personal beliefs that provide a barrier to new ideas. Rather than directing energy into forcing square pegs into round holes, curriculum innovators should seek ways that make it possible for people to accommodate new ideas within the constraints of their personal belief systems. I believe it to be unrealistic to expect teachers to simply abandon deeply rooted beliefs in favour of someone else's ideas. If their beliefs are known, the reasons for resistance become clearer

and it may be possible to see a way forward. This is particularly relevant as the drive to implement a new school curriculum based on Outcomes Based Education gathers momentum.

The study of teacher thinking is fairly widespread overseas, as evidenced in a review of the field by Thompson (1992). However, I have come across little research done in this country, especially amongst preservice teachers. The history of our country, and the cultural diversity of its people make it unlikely that home grown research will yield identical results to those obtained in Europe and the United States.

## CHAPTER 2

### CONCEPTUAL FRAMEWORK

#### 2.1 INTRODUCTION

In this chapter I discuss the conceptual framework that guided my thinking and the analysis of the data in this study. Arising from the factors mentioned in the discussion of the motivation for this study, (see page 1), I identified four main themes for investigation. These are

- the structure and content of a professional Mathematics Education course
- the notions of beliefs and personal theories and using metaphors to enable preservice teachers to articulate their own personal theories
- the impact of personal theories on classroom practice
- the disposition of preservice teachers to amend their personal theories.

A survey of the literature provided some structures and principles that were used in the later analysis of the data from this study.

#### 2.2 COMPONENTS OF A MATHEMATICS EDUCATION PROGRAMME

This study is set in the context of a Teacher Education College in KwaZulu-Natal, South Africa, and in particular, within a course in Mathematics Education. Due to changes in education policy, new norms and standards have been prescribed for teacher education, necessitating the development of new curricula to promote the required outcomes. This raises the question of what should form the core of a course designed to prepare students to effectively facilitate the learning of Mathematics in the secondary school.

At Edgewood College of Education, the secondary teacher trainees study towards a Diploma in Secondary Education. In the past they were allocated lectures for their major subjects, say Mathematics, and the Mathematics Education component had to come from that allocation. Traditionally it was considered as the methodology of teaching the subject and an ad hoc sort of “how to teach it” programme. Being non-examinable gave the course low status, and it was often sidelined in favour of the academic subject content which was examinable. A new curriculum introduced in 1997 resulted in Mathematics Education becoming an examinable

part of the Professional Studies component of the Diploma course. This separated and protected it from the academic Mathematics course and provided the imperative to design a separate Mathematics Education course based on well reasoned principles. Whilst the Norms and Standards for Educators (Technical Committee on the Revision of Norms and Standards for Educators, 1998) provide some general guiding principles for South African teacher educators, it maybe useful to consider international perspectives and personal experience as well.

My aim for a Mathematics Education course is to prepare preservice teachers to effectively facilitate the learning of Mathematics in schools. This led me to consider the aspects that might contribute to effective Mathematics teaching. Common sense told me that teachers must themselves have Mathematical knowledge and endless stories of teachers who were “too clever to teach” told me that this was clearly not enough. Teachers need ways to make Mathematical knowledge accessible to learners and the classroom skills to create a suitable learning environment. These aspects deserve attention in a Mathematics Education course.

These intuitive ideas of aspects that need attention in a Mathematics Education course are supported in the literature. McDiarmid, Ball and Anderson (1989) provide five suggested areas of study for those seeking to design a course for beginning teachers of Mathematics.

- Teacher Education students’ conceptions of teaching and learning
- Prospective teachers’ understanding of subject matter
- Learning to learn about pupils in relation to specific subject matter
- Evaluating representations of subject matter
- Generating representations of subject matter

Of particular interest to me were the four foci for a preservice Mathematics Education programme suggested by Manouchehri (1997). These are discussed below in relation to my initial intuitive ideas and the five suggestions made by McDiarmid et al. (1989).

Content knowledge: Few would contest that a teacher needs to know the subject to be taught and in fact this is the second of the areas suggested by McDiarmid et al. (1989) for attention in a Mathematics Education course. In the case of Mathematics this would mean that a teacher should personally be able to meet the demands of the subject beyond the level at which it is

taught. Secondary school teachers have traditionally had degree courses in the subjects they teach. An in-depth understanding of key facts, principles and concepts is required.

Pedagogical Content Knowledge: This is knowledge of the subject supplemented with knowledge of students and of learning. This would include an understanding of the “big picture” of school Mathematics, multiple representations of the concepts and methods of lesson presentation. A distinction is drawn between the mathematical knowledge of a pure mathematician and the mathematical knowledge required for teaching. Pedagogical content knowledge encompasses the last three of the areas suggested by McDiarmid et al. (1989), namely learning to learn about pupils in relation to specific subject matter, evaluating representations of subject matter and generating representations of subject matter. This seems to me to what is commonly referred to by scholars as “getting down to our level” and “being able to explain things”.

Pedagogical Reasoning: This is the process of transforming pedagogical content knowledge into forms suitable for particular learners in particular contexts so as to facilitate learning. I understand this to be a reflective thoughtful attempt to organise an environment in which learning can occur. The teacher obviously develops skill in pedagogical reasoning with experience, but there is a place in education courses for examination of case studies, simulations and lesson observations, so that principles can be established. I would add to this focus, general pedagogical skills and techniques such as questioning, assessment alternatives, materials development, classroom control and classroom management - all of which contribute to the learning environment. Little content knowledge or pedagogical content knowledge can be utilised in an undisciplined and rowdy classroom.

Beliefs: Manoucheri (1997) and McDiarmid et al. (1989) agree that what teachers believe about the nature of Mathematics, and the teaching and learning of Mathematics has a profound influence on the way they teach and facilitate learning. Consequently, the personal theories of preservice teachers deserve attention in a Mathematics Education course. The aggregate of each teacher’s beliefs and opinions forms his or her personal theory of Mathematics teaching and learning. This personal theory may be implicit and expressed only in the actions of the teacher and the way in which he or she makes sense of the educational situation, or it may be made explicit by a clearly thought out and articulated statement.

Consideration of these four foci leads me to liken successful Mathematics teaching to a four-legged table, with each of the foci being a leg. The table is unstable if any one of the legs is

short, and while it may appear to balance, the slightest pressure will cause a wobble. Subject content knowledge has an established place in the current College curriculum and is in fact given the status of a major subject. Pedagogical reasoning is dealt with in a General Methods course run by specialists in classroom practice, and pedagogical content knowledge is left for the subject methodology course. A noticeable gap, evident in the Norms and Standards for Educators document (Technical Committee on the Revision of Norms and Standards for Educators, 1998) as well as the current Mathematics Education curricula of Colleges of Education, is a focus on the personal theories and beliefs of the preservice teachers. This was not an area that I myself had considered prior to reading the literature for my studies towards a Masters degree in Education. This is an important omission if we are to accept Manouchehri's view that "teacher education programmes must challenge students' beliefs about the adequacy of their knowledge base for teaching and help them make implicit beliefs about teaching, learning, subject matter, and learning to teach, explicit" (Manouchehri, 1997). I had not seen, nor myself given any attention to the personal beliefs of preservice teachers in the College curriculum and I regarded this as a distinct weakness and possible cause of "wobbly" teachers. I made the exposing of implicit beliefs a focus of the Mathematics Education course within which this study is set.

Although it was clear to me that all preservice teachers have a store of ideas about teaching and learning Mathematics, it was not clear whether, for the preservice Mathematics teachers, these personal ideas were conscious or acknowledged as a fruitful area of study. The question arose as to whether it was intuitive to explore one's own thinking and to give value to personal theories and whether this would be seen as a contribution to professional development. This line of inquiry led to the first research question of this study.

Research Question One

**What is the perceived role of personal theories in the professional development of preservice Mathematics teachers?**

### **2.3 BELIEFS ABOUT TEACHING AND LEARNING**

A major theme of this study is the concept of personal beliefs and personal theories. Firstly, I will discuss the notion of beliefs in the general sense, then move on to a consideration of beliefs about teaching and learning, and finally narrow the focus to beliefs about teaching and learning Mathematics.



### 2.3.1 Beliefs

A discussion of the distinction between knowledge and beliefs may be helpful in clarifying concepts prior to a discussion of beliefs. Perhaps the most distinguishing feature is the certainty and validity traditionally associated with knowledge in contrast to the acknowledged disputability of beliefs. Philosophers deny that people know if their “knowledge” is invalid, but allow that people can believe independent of the validity of their belief (Thompson, 1992). This means that knowledge is objective and so there should be consensus among all who know and so there can be no personal knowledge. On the other hand, the subjectivity of beliefs and the understanding that other people may have contrary beliefs, supports the notion of an individualised set of beliefs which form a personal theory.

Of particular interest is what Mahlios and Maxson (1995) describe as root beliefs, that is beliefs that influence and shape one's actions and ideas. A personal belief in gender equality could be a root belief since it is likely to influence how a person treats other people, raises children, and interacts with learners in the classroom. Green (as cited in Thompson, 1992), has identified three dimensions of personal belief systems which may be helpful in understanding how teachers think.

1. Beliefs are held in relation to each other with some beliefs being primary beliefs and others being derivative beliefs. The latter are a logical consequence of the former. For example, a primary belief that Mathematics is a set of rules to be mastered may result in a derivative belief that drill and practice is the best way to learn Mathematics.
2. Beliefs are not all held with the same degree of conviction. Central beliefs are the most strongly held beliefs while peripheral beliefs are more susceptible to change. It does not follow necessarily that primary beliefs are central.
3. Beliefs are held in clusters that may be isolated from clusters of beliefs relating to other issues. This allows a person to experience no apparent tension while holding seemingly inconsistent personal beliefs.

If a person is able to hold contradictory or incongruous beliefs without sensing any conflict or tension, that person is said to be manifesting isolation in their conceptual system. On the other hand, a person who holds beliefs that are interrelated and support each other is manifesting integratedness in their conceptual system (Thompson, 1984, p.123). It is helpful for the preservice teachers' self-understanding to have a clear idea of the status and relationships

between their beliefs. In order to promote conceptual change, it is important for a facilitator to identify and understand the primary beliefs of teachers but to target peripheral beliefs as being the most amenable to change (Thompson, 1992). It has been observed that some teachers adhered to their beliefs and views with greater consistency than did others, and that a possible factor in determining this consistency was the reflectiveness of the teacher. Reflectiveness also influences the consistency of the relationship noted between beliefs and instructional practice (Thompson 1984).

Argyris and Schön (1974) draw the distinction between the espoused theory of a person, which is essentially what a person professes to believe and their theory-in-use which is the theory that governs their actions. These two personal theories may or may not be compatible. A person might find it relatively easy to describe and make explicit their espoused theory but their theories-in-use are seldom conscious and so are difficult to articulate. The theories-in-use are often unexamined and implicit and can be only be inferred from the practice of the teacher. Argyris and Schön (1974) in fact contend that "we cannot learn what someone's theory-in-use is simply by asking him" (p.7). Espoused theories are of academic interest only; the theories that affect the lives of the young people in the classrooms are the theories-in-use of their teachers.

### **2.3.2 Conceptions about Teaching and Learning**

Teachers possess conceptions about teaching in general, as well as conceptions specifically related to Mathematics teaching. They would also normally possess conceptions about the social class and academic ability of the class, and no doubt the same spread of prejudices and stereotyping common to the rest of the population. Thompson (1984) suggests that in some cases, these conceptions may take precedence over views and beliefs specific to Mathematics teaching. It is possible that for some preservice teachers, the conceptions about teaching and learning in general are primary beliefs and those relating to Mathematics teaching and learning are derivative beliefs.

What conceptions regarding teaching and learning are commonly held? It is interesting to see that studies undertaken in different countries and within different contexts yield similar sets of conceptions, but it should be noted that the description of categories and their hierarchical order are personal to the researchers concerned and cannot be assumed to be universal. The

studies that will be discussed in the following sections focus on either the teaching or the learning aspect of the educational process. Although something of the other face of the teaching/learning coin can be inferred from the conceptions, this is not made explicit.

### *Personal conceptions of learning*

Säljö (as cited in Marton, Dall'Alba and Beaty, 1993) identified and described five distinctly different conceptions of learning held by university students. As a result of research undertaken with students of the Open University in Britain, Marton et al. (1993) confirmed Säljö's five conceptions and added a sixth.

The six conceptions (in order of sophistication and quality) are a view of learning as:

1. Increasing one's knowledge: Learning is gaining more knowledge. The knowledge is regarded as having a discrete and quantifiable nature, and learning occurs when pieces of knowledge are transferred or picked up by the learner.
2. Memorising and reproducing: This conception is closely related to the first; the distinguishing characteristic being the purpose for which the learning is undertaken, namely to reproduce the knowledge for some form of assessment.
3. Applying: In this case, what is learnt is the ability to apply some knowledge or procedure at an appropriate time. Van Rossum, Deijkers and Hmer (as cited in Boughey, 1997) describe this as "the learning of algorithmical applications of this knowledge (at a later moment)". This phrasing has a familiar ring to Mathematics Educators who spend a great deal of time and energy providing learners with a "toolkit" of procedures and algorithms for future use.
4. Understanding: This is the first of the conceptions in which the notion of meaning is introduced. Learning is seen as a sense-making activity involving questioning and explanations.
5. Seeing something in a different way: This conception describes a consequence of developing an understanding of some idea or knowledge, namely the ability or disposition to discern certain phenomena in different ways and from different perspectives.
6. Changing as a person: This conception builds on the previous one in the following way.

By developing insights into - or a view of - the phenomena dealt with in the learning material, one develops a new way of seeing those phenomena, and seeing the world differently means you change as a person. (Marton et al., 1993, p.292)

Some of the data relating to the personal theories of the preservice teachers in this study was in the form of metaphors. For this reason, it is interesting and informative to consider the

metaphors which Marton et al. (1993) consider to be associated with each of the six conceptions. The first three conceptions are characterised by consumption metaphors such as “taking in”. The fourth conception, learning as understanding, is explained in terms of visual metaphors such as “looking into” the learning material, and “having a view” of things. The fifth conception, learning as seeing something in a different way, is characterised by an emphasis on the second of the visual metaphors, i.e. “looking at” some phenomenon. This is explained as follows:

The “looking into” metaphor implies that the whole is given to begin with and the parts are discerned subsequently. In the fifth conception, the “looking at” form dominates. Emphasis is placed on the way in which things are seen from different perspectives; things already discerned are seen as being related to other things or as being parts of greater wholes. (Marton et al., 1993, p.291)

No particular metaphor is suggested for the conception of learning as changing as a person, but our attention is drawn to the “strong organic nature of the metaphor” used in a quote deemed to be illustrative of this conception (Marton et al., 1993, p.293). There is no discussion of the role of the teacher in the six conceptions of learning identified above. How, and by whom, the learning is facilitated is not explicit.

A later study by Aguirre and Haggerty (1995) investigated the conceptions of learning held by science graduates in a preservice teacher education programme in Canada. They found a wide range of ideas about teaching and learning, with the preservice teachers seeming to have clearer views on teaching than on learning. The most prevalent view of teaching was identified as the “transmission of information” (p.120). Information regarding the conceptions of learning of the preservice teachers was gleaned from a series of interviews. The study had a phenomenographic orientation in that the conceptions rather than the individual participants were categorised. The researchers sought to construct a view of learning based on the conceptions evident in the data. Using their framework, the resultant analysis revealed seven dimensions of the conceptions of learning, namely:

awareness	↔	unawareness
private	↔	public
affective	↔	neutral
rote	↔	meaningful
tacit (incommunicable)	↔	explicit (communicable)
context free	↔	context dependent

automatic retrieval ↔ non-retrieval

The shades of meaning are subtler than is of interest in a study of a broader conception of teaching and learning, but some of the dimensions are of particular interest. The fourth dimension, rote - meaningful, was further divided into six categories to account for the range of conceptions. These six categories were:

1. Memorisation is part of learning
2. Learning is thinking and understanding
3. Learning is assimilating a new concept into your own perspective
4. Learning is an integration of conceptions
5. Learning is an internal struggle between old and new conceptions
6. Learning is changing a perspective

From this it is evident that all but the additional sixth conception of learning identified by Marton et al. (1993) fall under this rote - meaningful dimension. The remaining conception, learning is changing as a person, is part of the private - public dimension in which learning is described as “an incorporation of public ideas and knowledge for personal growth” (p.124). Aguirre and Haggerty (1995) contend that their study has tapped conceptions that Marton et al. (1993) did not uncover since the latter’s categorisation touches only two of their seven dimensions. I think the focus of the studies is different with many of the dimensions identified by Aguirre and Haggerty (1995) seeming to be descriptions of characteristics of learning rather than basic conceptions of learning.

Sfard (1998) simplifies the categories of conceptions of learning into two main ideas, described as the acquisition metaphor and the participation metaphor. A further discussion of the use of metaphors to express ideas follows on page 26. The acquisition metaphor is probably typified by the "conduit metaphor" referred to by Reddy (1978). Sfard (1998) points out that this conception of knowledge as a commodity, and learning as the acquisition of something, has its roots in ancient times, and has only recently been challenged. Although many researchers have investigated the methods by which learners might gain possession of the knowledge, there was little controversy over the notion that this was the essence of learning. This metaphor implies that learning has an endpoint - once the knowledge is successfully transferred. The second metaphor identified by Sfard (1998) is the participation metaphor, which, as the name suggests, describes learning as the process of becoming a member of a community, with the implication of familiarity with the norms and discourse of the group. Learners are actively

engaged in increasing the extent of their knowing and an end to learning is not envisaged. This seems to capture the spirit of current statutory requirement for teachers to be lifelong learners (see page 4). Sfard (1998) does not anticipate that a person's personal theory will be neat and well defined.

A realistic thinker knows he or she has to give up the hope that the little patches of coherence will eventually combine into a consistent global theory. It seems that the sooner we accept the thought that our work is bound to produce a patchwork of metaphors rather than a unified, homogeneous theory of learning, the better for us and for those who lives are likely to be affected by our work. (p.12)

Even if a consistent and coherent personal theory is unlikely, I consider an attempt to articulate personal beliefs to be a valuable and a significant part of professional development. A large part of this study was concerned with eliciting the personal theories of preservice teachers. Once articulated, these personal theories could be scrutinised and reworked if so desired.

### *Personal conceptions of teaching*

This section deals with conceptions of teaching that should be seen as complementary to the conceptions of learning discussed in the previous section. Several of the activities of the Mathematics Education course in which this study was situated, and the analysis of the data from this study was based on the personal theories of teaching suggested by Fox (1983). I chose to use these theories of teaching as a basis for this study for two main reasons. Firstly, the article by Fox (1983) was read subsequent to an initial study of student metaphors for teaching and learning Mathematics. The themes found in these metaphors had an echo in Fox's classification which inspired confidence in his analysis. Secondly, the fact that Fox described the personal conceptions of teaching metaphorically, fitted very neatly with my research instrumentation.

Following his work with University lecturers, Fox (1983) constructed four categories of personal theories of teaching. These are described metaphorically as follows:

Transfer theory: Knowledge is viewed as a commodity to be transferred from one container to another – the pouring action being the teaching. It follows from this conception that the teacher initially has the knowledge and good teaching consists of strategies to pass this knowledge on. This would include the preparation of clear and interesting lectures and detailed lecture notes.

Shaping theory: Teaching is viewed as a process of shaping or moulding learners into a particular form. The teaching act comprises detailed step – by – step instructions regarding a procedure, followed by supervised practice until the desired skills are mastered. The teacher has a dominant role as the expert and master of the procedures while the role of the learner can be likened to an apprentice.

Travelling theory: Teaching is viewed as the exploration of a subject in the same way as a traveller would explore terrain in the company of an expert guide. The teacher is familiar with the terrain and knows the shortcuts and best vantage points. He or she shares this knowledge and expertise with the fellow travellers. There is a sense of working together, but also a sense of each traveller having his/her own purpose and interests.

Growing theory: Teaching is seen by “growing” theorists to be more concerned with the personal development of the individual learner than the actual subject matter content. The students’ minds are viewed as fertile soil with all sorts of plants already growing. Teaching is a matter of helping the student to tidy up the garden, retaining what is worthwhile and possibly taking in new plants and developing new or different overall garden plans.

Fox (1983) describes two overarching categories for theories of teaching – namely simple and developed theories. The transfer and shaping theories are simple theories, distinguished by the fact that the teacher is the sole owner, purveyor and shaper of the commodity of learning. The travelling and growing theories where the students and teacher are regarded more as partners in the learning process are described as developed theories. A further distinction between the four conceptions of teaching lies in the focus of the teaching. In the transfer and travelling theories, the verb “teaching” applies to the subject content, and so a teacher might say that he/she teaches Mathematics. The verb “teaching” applies to the student in the shaping and growing theories, and a teacher in this case would say that he/she teaches undergraduate students.

It seems to me that the binary distinction drawn by Sfard (1998) between acquisition and participation metaphors for learning, and the distinction drawn by Fox (1983) between simple and developed views of teaching are very closely related. The further subcategories suggested by Fox provide a richer and more detailed framework for understanding the personal conceptions of teaching (and learning) held by the preservice teachers participating in this study, and the analysis in this study was based on Fox (1983).

### 2.3.3 Conceptions about Mathematics

Preservice teachers' personal beliefs about the subject Mathematics do not form a focus of this study. However such beliefs are relevant in that a personal theory of teaching and learning Mathematics is likely to be shaped in some way by a personal conception of the nature of the subject itself. Thompson (1992) describes a teacher's conception of the nature of Mathematics as "that teacher's conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences concerning the discipline of Mathematics" (p.132). This would form the beginnings of a personal philosophy of Mathematics.

Ernest (as cited in Thompson, 1992) has distinguished three conceptions of Mathematics.

1. A dynamic view, in which Mathematics is regarded as an incomplete and ever expanding human creation - the result of an ongoing search for patterns and relationships which can be formalised into new knowledge to be interrogated and contested by fellow Mathematicians.
2. The Platonist view, in which Mathematics is regarded as a complete and static body of knowledge with logic and structure. The role of Mathematicians is to discover and disclose this logic and structure.
3. An instrumentalist view, in which Mathematics is regarded as a collection of facts, rules, algorithms and skills to be mastered for some utilitarian purpose.

Although these seem to be mutually exclusive conceptions, Thompson (1992) considers it likely that an individual teacher's conception of Mathematics would include aspects of more than one of the above views. This would be explicable in terms of the clustering quality of belief systems described earlier on page 16, that allows an individual to isolate and therefore accommodate conflicting beliefs.

Skemp (1978) identifies two conceptions of the nature of mathematical understanding which link to the above conceptions of the subject Mathematics. The first is instrumental understanding that is based on knowledge of rules and algorithms to be applied in particular circumstances. This is easiest understood as "knowing how to do the problem". The second type of understanding is relational understanding which implies an understanding of how to do the problem coupled with an understanding of why the procedure works and how it relates to other areas of Mathematics. Skemp (1978) suggests that the classroom practice of teachers who hold each of these conceptions of mathematical understanding will differ to the extent that "there are two effectively different subjects being taught under the name Mathematics" (p.11). Teaching for instrumental understanding involves teachers demonstration of the techniques



followed by practice until the rules and procedures are mastered. On the other hand, teaching for relational understanding requires more learner-centered sense making activities and investigations. The rules and procedures become evident through such activities.

### **2.3.4 Conceptions about Mathematics Teaching and Learning**

It can be assumed that Mathematics teachers, either preservice or in-service would have, in addition to their conceptions about teaching and learning in general, some beliefs specific to the teaching and learning of Mathematics. Smith (1996) conveniently provides a summary of the results of a large number of studies of the conceptions, beliefs, and practices of prospective teachers. These relate to teaching Mathematics, learning Mathematics and authority in a Mathematics classroom and are outlined below:

- Mathematics is generally believed to be a fixed set of facts and procedures to be mastered. This is consistent with an instrumental understanding of the nature of Mathematics (see page 23) and a shaping theory of teaching (see page 21).
- Students learn by watching and listening to the teacher's demonstrations and explanations and refine their skills by practice. Success at Mathematics is dependent on the ability to remember the steps in each procedure and to recall which procedure is appropriate in each circumstance.
- The answers to the mathematical problems are known and available in textbooks. The teacher acts as an intermediate authority on matters of mathematical truth.

Smith (1996) contends that these beliefs are interconnected and mutually dependent. The strong link between personal beliefs and classroom practice that was a motivating factor for this study is further discussed on page 29.

Thompson (1992) notes that researchers have indicated that the formation of preservice teachers' beliefs about Mathematics teaching and learning occurs mainly during their school years and as a result of their own experiences as students of Mathematics. This view is supported by Smith (1996) who adds that as "listening students of Mathematics for 12 to 16 years, future teachers have extensive participation in the practice of teaching by telling" (p.391). It is easy to see how the conceptions listed above can support a novice teacher's sense of efficacy, since they result in a clearly defined process of teaching. Teaching by telling implies that the teacher is the authority figure who has control over the content to be presented in the lesson. This means that there is a fixed body of Mathematics to be mastered for each lesson,

which is comforting to a teacher who is unsure of the subject. Likewise, the steps and procedures involved in the particular type of problem for the day can be rehearsed, which reduces the number of embarrassing teaching errors. A teacher can feel a sense of pride and achievement when the learners have mastered the procedures (as evident from success in tests) since they were the source of the learners' knowledge. All of this leads to a sense of efficacy on the part of the teacher. It is understandable that teachers are loath to relinquish their deeply rooted beliefs and move out of their comfort zone into a classroom where pupils can question, the subject content is variable and their weaknesses may be exposed. Smith (1996) suggests that ways be investigated whereby new moorings (related to reform in Mathematics Education) be found for teachers' sense of efficacy.

The studies that provided the data motivating the classification of conceptions of teaching and/or learning described above, were all conducted outside South Africa. Do the preservice teachers in KwaZulu - Natal hold similar conceptions? Perhaps the unique circumstances in this country have shaped the thinking of preservice teachers differently, and certainly cultural beliefs could be expected to form part of their personal theories. Consideration of this issue prompted the second research question:

Research Question Two

**What personal theories about the teaching and learning of Mathematics do preservice Mathematics teachers hold?**

## 2.4 ELICITING PERSONAL THEORIES

In order to classify and study the personal theories of the preservice teachers participating in this study, it was necessary that such theories be made explicit and public. I adopted the notion that each person had some implicit personal theory that could be surfaced, but suspected that it would not be easy for people to come cold to the task of constructing or articulating personal theories. Following a discussion of teachers' implicit theories of teaching and learning, Clark and Peterson (1990) remark that "the central task of the researcher is to assist the teacher in moving from an implicitly held and private belief system to an explicit description of his or her cognitive frame of reference" (p.287).

Returning to the contention of Argyris and Schön (1974) that "we cannot learn what someone's theory-in-use is simply by asking him" (p.7), additional and alternative methods

must be sought to elicit the personal theories of people. Such methods could include asking the learners as well as the teacher, and observation of the classroom practice of the teacher. Discussion with peers is a good starting point but unfortunately as Argyris and Schön (1974) point out "individuals with skills, knowledge and values dysfunctional to constructing theories-in-use tend to create groups that reinforce their programming" (p.38). Thus individuals have to battle against both themselves and a group ethos which is contrary to reflectiveness. I considered the study of the metaphors used by people to describe the teaching/learning situation a promising vehicle for promoting reflection and surfacing personal theories. I hoped that the novelty of the notion of drawing pictures to metaphorically explain their personal beliefs might improve the disposition of the preservice teachers to engage in the task of articulating these beliefs. The use of metaphors for this purpose is discussed in the following section.

#### **2.4.1 Metaphors as a means of eliciting personal theories**

My interest in using metaphors as a method to elicit authentic student beliefs began at the outset of the Masters in Education course - during the first Module on Learning. I was concerned that simply asking a group of students who were in their final year of a Bachelor of Education degree, what they considered learning to be, would merely elicit a response that reflected what they recalled from Education courses as "correct" and currently acceptable. I had heard of a colleague using pictures depicting scenarios that could be considered metaphors for teaching and learning in his courses and consequently used these as a starting point for discussion. The students were required to both draw and describe a situation that they considered to be a metaphor for the teaching and learning of Mathematics. The results intrigued me as they were imaginative and insightful and I was persuaded that this was a valuable tool for eliciting student opinion and raising ideas for discussion. The dictionary definition offered by Collins Cobuild English Language Dictionary, (Sinclair, 1993, p.910), namely that a metaphor is "an imaginative way of describing something by referring to something else which has the qualities that you are trying to express", aptly describes the use of metaphors in this study.

My intuitive notion of the usefulness of metaphors is shared with many other writers in the field. Munby (1986) has concluded after his study on the metaphors used in the language of teachers, that "the concept of metaphor might be a powerful tool for investigating teachers'

thinking". Miller and Fredericks (1988) conducted a study of the metaphors used by education students in answering an examination question relating to effective teachers and effective schools. They suggest that metaphors are a potentially rich source of qualitative data and as such deserve to be incorporated into the body of qualitative research tools. These researchers dispute the positivist viewpoint that metaphors, being literally false, are unsuitable vehicles to describe reality. Rather they suggest that "the metaphor "captures" or "encapsulates" perception in a compact way that goes beyond a simple literal and "objectively" false view that knowledge can be "built"" (Miller & Fredericks, 1988, p.269). The process of identifying appropriate personal metaphors may lead to increased self- understanding. Rowntree (1981) concludes a discussion on student metaphors by remarking that "we can often obtain illumination by considering the metaphors or analogies that appear to describe the way teachers and students think of what they are doing" (p.105).

Just as in mutual understanding we constantly search out commonalities of experience when we speak with other people, so in self-understanding we are always searching for what unifies our own diverse experiences in order to give coherence to our lives. Just as we seek out metaphors to highlight and make coherent our own pasts, our present activities, and our dreams, hopes and goals as well. A large part of self-understanding is the search for appropriate personal metaphors that make sense of our lives. (Lakoff & Johnson, 1980, pp. 232-233)

Fox (1983) characterises learning as a "slippery concept" and certainly it is difficult to define. He suggests that people need analogies to help them pin down such concepts, and then goes on to provide four metaphorical analogies for teaching (see page 21). Metaphors provide a creative medium for expression, but can nevertheless be precise, concise and effective means of conveying ideas as suggested in the following extract.

What is ironic is that in the professional socialisation of educational researchers, the use of metaphor is regarded as a sign of imprecision; yet, for making public the ineffable, nothing is more precise than the artistic use of language. Metaphoric precision is the central vehicle for revealing the qualitative aspects of life (Eisner, cited in Janesick, 1994, p.209).

While metaphors about teaching used in everyday speech are probably unconscious, the metaphors in this study were explicitly solicited and consciously created - the process being as important as the product. The mere act of trying to put down on paper a personal metaphor involves some reflection, introspection, and progress towards self-understanding on the part of the person. Bringing to the open the tacit assumptions and beliefs that guide us "means digging out the metaphors that underlie both our spontaneous everyday conceptions and scientific theorizing" (Sfard, 1998, p.4).

Indeed, metaphors are the most primitive, most elusive, and yet amazingly informative objects of analysis. Their special power stems from the fact that they often cross the borders between the spontaneous and the scientific, between the intuitive and the formal. (Sfard, 1998, p.4)

Metaphors represent teachers' understanding about teaching and their conceptions of themselves as teachers, what has been termed their "professional identity" (Bullough, 1991, p.44). Although it would not be realistic to expect to find a single and simple metaphor that would neatly express a person's conception of teaching, I concur with Connelly and Clandinin (as cited in Bullough, 1991) that "it makes a great deal of difference to our practice ... if we think of teaching as gardening, coaching or cooking. It makes a difference if we think of children as clay to be moulded or as players on a team or as travellers on a journey." The metaphor that a person chooses to express their personal belief must reveal at least some important clues to their understanding of teaching and learning. Bullough (1991) persuades me that the tendency to oversimplify issues with metaphors is more a virtue than a failing of the methodology of using metaphors to express ideas. A metaphor provides a person with an opportunity to try to capture the essence of their conception in novel way - metaphors offer a different way of perceiving reality (Munby, 1986).

Generating a metaphor may also provide an impetus for a person to go forward in their thinking - once a metaphor is made explicit by drawing and writing, it is open for reconsideration. Sticht (1993) suggests that consideration of metaphor as a tool for thought is concerned with the discovery of relationships between seemingly disparate domains and the extent to which they can be related. The attempts to list the similarities and differences between these domains may lead to the discovery of relationships or differences not thought of at the time the metaphor was conceived. I think that this process has the potential to be helpful in exploring personal conceptions. Consideration of the personal metaphor of a colleague or fellow student may provide new perceptions and novel insights into familiar situations. Indeed, it is possible that people may find themselves uneasy if they are unable to create coherent and consistent metaphors. "The basic tension between seemingly conflicting metaphors is our protection against theoretical excesses, and is a source of power" (Sfard, 1998, p.10).

There seem to be three distinct methods used by researchers to obtain metaphorical data from participants in the study.

1. Some researchers focus on the linguistic aspects of metaphor, particularly as it occurs spontaneously in people's writing or speech (Miller & Fredericks, 1988; Munby, 1986).

Such spoken (or written) metaphors may provide some confirming evidence of students' beliefs as suggested in their writings or in oral interviews.

2. Mahlios and Maxson (1995) obtained their data by asking preservice teachers to select from a prepared list of metaphors for their schooling, life and childhood.
3. Other researchers have asked teachers to generate their own metaphor to describe their beliefs and images of particular aspects of teaching. (Bullough, 1991; Weinstein, Woolfolf, Dittmeier & Shanker, 1994).

I chose this latter, more open approach to the task of eliciting metaphors for the teaching and learning of Mathematics. I felt that it allowed for more creativity, and participants in the study would not be influenced by a prepared list.

In this study preservice teachers were asked to use metaphors to capture the essence of the whole Mathematics teaching and learning experience. Many of the metaphors alluded to in the literature refer to a particular player in this scenario, usually the teacher. (Bullough, 1991; Weinstein et al., 1994; Mahlios & Maxson, 1995). Teachers are described as policemen, prison guards, shepherds, mother birds and so on. I considered the task of suggesting a metaphor for the entire learning situation to be richer in that the implications of a particular conception of the teacher for the learners has to be considered. For instance, it does not seem to make sense for teachers to conceptualise themselves as shepherds if the learners are not conceptualised as sheep.

## **2.5 PERSONAL THEORIES – DO THEY MATTER IN THE CLASSROOM?**

The studies discussed above have used metaphorical analysis to gain knowledge about the conceptions people have of teaching and learning. In the motivation for this study (see page 7), it is conjectured that the personal theories of preservice teachers exert a significant influence on their classroom practice. Considerable evidence, as discussed below, has been gathered to support this view.

Aguirre and Haggerty (1995) suggest that the informally developed and atheoretical views of learning expressed by the preservice teachers in their study are likely to influence the early years of their teaching careers. Thompson supports this view.

There is strong reason to believe that in Mathematics, teachers' conceptions (their beliefs, views and preferences) about the subject matter and its teaching play an important role in affecting their effectiveness as the primary mediators between the subject and the learners. Yet, very little is known about the role that these conceptions might play in the formation of instructional practices characteristic of their teaching. (Thompson, 1984, p.105)

In addition, the teacher education instructors should be aware of the particular views held by their students, especially given the fact that research seems to indicate “that learners at all levels tend to maintain their prior conceptions about phenomena despite instruction” (Thompson, 1984, p.130). The preservice teachers themselves are often unaware of their own beliefs, and the implications these might have.

We have found that future teachers with whom we worked often were unaware of the values and beliefs they brought into the classroom. Although values influence everyone's work and can strengthen teaching and interactive abilities, awareness of what these values are helps us see how they shape our attitudes towards students (and other educators). (Bogdan & Biklen, 1992, p.219)

This is endorsed by Manouchehri (1997) who reports that research consistently shows that teachers translate their knowledge of Mathematics and pedagogy into practice through the filter of their beliefs. Further, implicit beliefs can prove a barrier to innovation in the sense that “if teachers’ implicit theory about learners or their mental image of effective teaching were contrary to that embodied in a new curriculum or experimental teaching method, they would be unlikely to bring the innovation alive with great enthusiasm, thoroughness and persistence” (Clark & Peterson, 1990, p.292).

Teaching is essentially about people, and cannot be divorced from the personalities involved. I deem it unlikely that a teacher would be able to consistently play out a classroom role in conflict with their personal beliefs about life in general and teaching and learning in particular. Clark (1995) supports this by noting that:

Teachers teach in the way they do not just because of the skills they have or have not learned. The ways they teach are also grounded in their backgrounds, their biographies, in the kinds of teachers they have become. (p.ix)

I think it is important for teachers themselves to recognise this and to try to develop some sense of self-knowledge.

How will the surfacing and exposing of personal theories to scrutiny assist in the professional development of the preservice teacher? Firstly, the link between personal theories and the daily business of teachers, i.e. classroom practice, needs to be discussed. The appreciation of a

causal relationship between personal theories and classroom practice could lead to greater importance being attached to personal theories. This relationship has been clearly indicated in the literature discussed above but may not be apparent to preservice teachers. Consequently I posed the following research question:

Research Question Three

**Are preservice teachers aware of the links between their personal theories and their classroom practice?**

## 2.6 CHANGING AND ADAPTING PERSONAL THEORIES

The Mathematics Education component of preservice teacher education provides an opportunity for examination of personal theories.

The task of modifying long-held, deeply rooted conceptions of Mathematics and its teaching in the short period of a course in methods of teaching remains a major problem in Mathematics teacher education. (Thompson, 1992, p.135)

It could be expected that the particular metaphors for the teaching and learning of Mathematics favoured by the facilitator of a Mathematics Education course would have some influence on the thinking of the preservice teachers. However Rowntree (1981) notes that this influence may be regrettably small due to a situation in which "students are simply too attuned to the metaphors that predominate in other courses and in the institution as a whole"(p. 102).

I agree with Bullough (1994) that the prime factor in effecting reform is imagination or a vision of how things could be. "To imagine the world not as it is necessitates uncovering the implicit theories, the metaphors that quietly shape thinking and limit alternatives; the power of metaphors is directly related to how well or poorly they are known" (Bullough, 1994, p.4). Sfard (1998) describes personal metaphors as a double-edged sword since on the one hand they make our abstract thinking possible, but on the other hand they might keep our human imagination within the confines of former experience and conceptions. "Different metaphors may lead to different ways of thinking and to different activities. We may say, therefore, that we live by the metaphors we use" (Sfard, 1998, p.5).

What teachers believe about the nature of Mathematics and teaching and learning Mathematics has a profound influence on the way they teach and facilitate the learning of Mathematics. The



beliefs held by students are a result of twelve years of schooling and possibly some tertiary Mathematics experience and can be expected to be strongly rooted and resistant to change. Argyris and Schön (1974) suggest that the struggle people have in learning new theories of action may not entirely be attributable to the inherent difficulty of the new theories but in part to the existing theories people have that already determine practice. They raise the question of whether "the difficulty in learning new theories of action is related to a disposition to protect the old theories-in-use" (p.vii).

Teachers may construct personal theories that rationalise or excuse their behaviour in some way. For example, a theory that the teacher must explain all new mathematical material protects a teacher from criticism for providing very few individual sense-making activities. Such theories in turn then may become obstructions to teachers' improvement of their own practice and affect their response to attempts to innovate (Calderhead, 1987, p.12).

Thompson (1984) observed that some teachers seemed to adhere to their beliefs and views with greater consistency than did others, and that a possible factor in determining this consistency was the reflectiveness of the teacher. Developing reflectiveness is a very challenging task and may not even be sufficient to promote change. Francis (1997) expresses doubt that reflection will necessarily enable teachers to see through the political, social and cultural ideologies embedded in their action. "What they do and what they are able to see is so inscribed in their being that implicit knowings are reconstituted, albeit using different strategies" (Francis, 1997, p.172).

Thompson (1992) discusses the observed phenomenon of Mathematics teachers' resistance to innovative ideas that conflict with their personal belief systems or schema. It seems that teachers are more likely to try to modify new ideas to fit in with their existing schema than they are to reconceptualise their belief systems. This was supported by a study by Olsen (as cited in Clark and Peterson, 1990). In this study a group of teachers involved in the implementation of a new curriculum experienced a tension between their implicit theory of teaching which included a belief that teacher influence in the classroom should be high, and the underlying principle of the new curriculum which advocated reduced teacher influence in the classroom. "Domesticating" the new curriculum to the extent that it became compatible with their implicit theories eased this tension for the teachers.

It seems clear that amending personal beliefs and theories requires effort and motivation on the part of the teacher. Hill (1997) devised a programme based on the model for conceptual change proposed by Posner et al. in 1982 (as cited in Hill, 1997). These researchers identified four conditions necessary for conceptual change to occur.

1. An awareness of, and dissatisfaction with their current conceptions
2. An awareness and understanding of a new idea
3. A belief that the new idea is plausible and worthwhile and will contribute to the solution
4. A belief that it is worthwhile to invest time and effort in the new idea, in other words they must be convinced of the fruitfulness of the new idea.

Skemp (1978) casts doubt on even the conditions mentioned above being sufficient to ensure change in thinking. He mentions “the great difficulty for teachers of accommodating (restructuring) their existing and longstanding schemas, even for the minority who know they need to, want to do so, and have time for study” (p.13).

A teacher’s sense of efficacy is supported by the achievement of “a job well done”. There is no doubt that teachers feel satisfied at the conclusion of a well prepared and expertly delivered lesson that they have done their job well and covered the work. The same sense of satisfaction is not so evident after a session helping (or watching) learners battle through some work with no guaranteed progress or conclusion. This observation led Smith (1996) to identify the strong link between teaching by telling and the teacher’s sense of efficacy to be a barrier or challenge to reform. Current reforms in Mathematics Education which suggest a metaphor of teachers as guides or facilitators seem to “challenge the fundamental assumption that teachers can be direct causal agents in student learning” (Smith, 1996, p.388).

Arising out of their work with preservice teachers who had generated metaphors, Bullough and Gitlin wrote:

And finally, we stress over and over again that there is no universal, single, best teaching metaphor. We remind them that all metaphors have limitations and break down as comparisons are made. Moreover, we suggest that as their thinking becomes more complicated, other metaphors may become more compelling than those initially generated, and that this is the way it is supposed to be; it is a sign of development as a teacher. (Bullough & Gitlin, 1995, p.70)

The research discussed above tells of the difficulty teachers experience in changing their views, even when they have the will to do so. However, there is unlikely to be any change in the

personal theory of a person who considers his/her theory complete and fully thought out. A pre-requisite for openness to change would be a realisation that one's personal theory is still in the developmental stage and so a process of change is possible if not inevitable. This relates directly to the requirement found in the Norms and Standards for Educators document (Technical Committee On the Revision of Norms and Standards for Educators, 1998) that teachers should be scholars, researchers and lifelong learners (see page 4).

The following and final research question is concerned with openness to change.

#### Research Question Four

**Do preservice teachers view their personal theories as developing or complete?**

## 2.7 SUMMARY

A preservice Mathematics Education course represents an interlude between the school experience of prospective teachers and their future teaching experience. As such, it provides a unique and ideal opportunity for preservice teachers to pause, articulate and reconsider their inherent beliefs about the teaching and learning of Mathematics. There are several demands made on the time allocated to the Mathematics Education course, but the significance given by writers in the field to the personal theories of preservice teachers, allows a consideration of beliefs to stand along with subject content knowledge, pedagogical content knowledge and classroom skills as an important component of the course. Whether or not the preservice teachers themselves intuitively see a consideration of their personal theories as a valuable part of a Mathematics Education course is the subject of the first research question.

The second, and major focus of this study is the consideration of the nature of the personal beliefs about the teaching and learning of Mathematics that are held by the preservice teachers. These beliefs can be classified and general themes in the thinking of the preservice teachers can be identified. Articulating a personal set of beliefs requires people to stop and think a while. The technique of asking preservice teachers to draw and describe metaphors for the teaching and learning of Mathematics could be used as an aid to this thought. Metaphors provide people with an imaginative and often novel means of expressing their thoughts.

The "so what?" question that naturally follows an exercise to articulate and reflect on personal theories deserves attention. Why does it matter what preservice teachers think about the teaching and learning of Mathematics, and why should they engage in the task of making their

personal theories explicit? It is suggested firstly that personal theories are intrinsically linked with the classroom practice of teachers and so they would certainly matter to the learners in the classroom, and secondly, that personal theories act as a barrier to new ideas and serve to prevent teachers from accepting innovations. The time and effort expended by the preservice teachers in articulating their personal theories is an investment in their own professional development. The investigation of the awareness that the preservice teachers had of the link between personal theories and classroom practice, formed the third focus of this study.

Although no assumption of deficit can be made regarding the nature of the personal theories of the preservice teachers, it would be hoped that they would not themselves regard their personal theories as permanent at this early stage of their professional lives. The literature on the notion of teacher change is extensive, and points to the difficulty that teachers experience in changing their beliefs and accepting new ideas. The final focus of this study is related to willingness of preservice teachers to amend their initially expressed personal theories in response to experience in the classroom and discussions with fellow preservice teachers.

The following chapter describes the research methodology employed to answer the four research questions that are highlighted in this chapter.

## CHAPTER 3

### RESEARCH METHODOLOGY

This chapter describes the methods used to elicit and describe the implicit personal theories of Mathematics teaching and learning held by preservice Mathematics teachers, and to investigate any changes that might occur in their thinking. Since the intention of the study was to identify and understand the points of view of the participants and the meanings they attach to teaching and learning Mathematics, a qualitative approach was deemed appropriate.

#### 3.1 CHOICE OF METHODOLOGY

Qualitative research is an approach that together with ethnographic and case study research, falls under the umbrella heading of interpretive research. Diverse approaches to interpretive research are connected by the researcher's intention to investigate the actions and interactions of participants within an educational milieu and to understand those actions and interactions from the perspectives of the participants (Erikson, 1998). Although not precluding statistics nor rigor, qualitative research de-emphasises rigorously measured processes and meanings, and consequently does not result in the same neat statistical results as quantitative research. This has led to qualitative researchers being dubbed, with some disapproval, "journalists or soft scientists" (Denzin & Lincoln, 1994). Some insight into the field of qualitative research is gained by a consideration of its historical development.

##### 3.1.1 History of qualitative research

During the nineteenth century in the United States, there was a move towards social investigation into the plight of the poor and oppressed of the time. Researchers sought to describe and document in detail, the day to day lives of these people with the intention of encouraging social change. Social anthropologists who turned their attention from native cultures in remote areas abroad to the cultural issues at home sustained this trend from the 1930's to the 1950's. Their research methods were applied successfully to United States culture.

By the 1960's, educational researchers themselves had turned to qualitative approaches, which although not yet firmly established as legitimate research paradigms, were beginning to engender interest. Qualitative description offered a way of gaining insight into the lives of the "other half." Further, "qualitative methods gained popularity because of their recognition of the views of the powerless and the excluded" (Bogdan & Biklen, 1992, p.21), and this was in line with the democratic spirit of the time. The ensuing three decades saw a greater acceptance of qualitative research and a softening of the hard divide between qualitative and quantitative methodologies. Qualitative research found favour among feminist researchers who perceived the "poor and oppressed" of their time to be women, and were "attracted to quantitative methods because they enabled the interpretations of women to take centre stage" (Bogdan & Biklen, 1992, p.27). Feminists highlighted the political implications of social research.

Despite the increase in application of qualitative methods to research problems in the social sciences, Richardson comments that:

Qualitative research has still to achieve parity with established, quantitative forms of inquiry in terms of prestige, access to funding and publications, and integration into the curriculum. (Richardson, 1999, p. 54)

### **3.1.2 The suitability of a qualitative approach to this study**

As a Mathematics Educator, the appeal of a quantitative method that would yield numbers to analyse and manipulate was strong. Nevertheless, the research methodology chosen must be the best and most appropriate way to answer the particular research questions of the study and quantitative methods, with the emphasis on measurement conducted in a presumed value-free framework and analysis of causal relationships between variables (Denzin & Lincoln, 1994), are unlikely to be helpful in understanding the thinking of people. Quantitative studies are restricted to that which can be measured which tends to oversimplify issues. Qualitative methods which involve the collection of a variety of empirical materials such as participant's writings, interview transcripts and researcher's observation notes are more likely to be helpful in understanding factors such as beliefs, emotions and attitudes which are not easily quantified. Consequently a qualitative rather than quantitative methodology seemed suitable to the purposes of this study.

Erickson (1998) provides some instances in which qualitative methodology could be helpful.

Qualitative research in education is especially appropriate when we want: detailed information about implementation; to identify the nuances of subjective understanding that motivate various participants in a setting; to identify and understand changes over time. (Erickson, 1998, p.1155)

The second two of these instances are particularly applicable to this study which seeks to provide a description of the thinking of a particular group of preservice teachers and their points of view on teaching and learning Mathematics, and to monitor any changes in this thinking over the year. The emphasis is neither on the correlation between variables nor the search for significant trends and relationships within a large data pool. An investigation of people's beliefs and consequent actions is by nature subjective and prone to interpretation in the light of the researchers own value system. Beliefs and ideas are better expressed in words and drawings than in numbers resulting from statistical analysis.

Consideration of the five characteristics of qualitative research suggested by Bogdan and Biklen (1992) further endorses the appropriateness of a qualitative methodology for this study.

These are:

1. Qualitative research has the natural setting as the direct source of data and the researcher is the key instrument.
2. Qualitative research is descriptive.
3. Qualitative researchers are concerned with process rather than simply with outcomes or products.
4. Qualitative researchers tend to analyse their data inductively.
5. "Meaning" is of essential concern to the qualitative approach.

This study is set in the context of a compulsory course for the preservice teachers and all the data was collected from activities that formed part of this course. This data was in the form of words or pictures, many of which are reproduced in this report to provide a rich description of the ideas of the participants in the study. The data in this study was analysed for themes in the personal beliefs of the preservice teachers and so fits with an inductive approach. Finally the fifth characteristic, that of investigating the perspectives and life views of the participants is a key feature of this study.

Gallagher (1991) stated that "science educators who engage in interpretive research are in the business of making sense of, and giving meaning to, the ways in which science teachers and

students make sense of, and give meaning to, their work in teaching and learning science”(p.7). Interpretive research will surely serve Mathematics teacher educators in the same way.

### **3.1.3 Phenomenography**

The qualitative approach adopted in this study has aspects of phenomenography. The word "phenomenography" has its etymological roots in Greek "phainomenon" and "graphein" meaning appearance and description respectively. The combination of these two words makes phenomenography a description of appearances. The phenomenographic researcher seeks to identify, describe and categorise the qualitatively different ways in which people report that they perceive phenomena. It is the conceptions and not the people that are described and categorised.

This approach has been used extensively by researchers into student learning in higher education, notably Marton and his colleagues (Marton, 1993). A characteristic is that the data comes directly from the participants in the study and is accepted by the researcher at face value. An attempt is then made to describe the world as people experience it. Initially, researchers obtained their data from transcripts of extensive interviews, but Marton (as cited in Richardson, 1999) recognised that there were other sources of information by means of which researchers could understand how people conceived of different aspects of their world. These included group interviews, observations, drawings and written responses. The latter two sources were used in this study.

The participants in the study, the instruments and opportunities for data collection and procedures followed in collecting the data will be described in the ensuing sections.

## **3.2 PARTICIPANTS IN THE STUDY**

The participants in this study were preservice Mathematics teachers studying at Edgewood College of Education situated 24 kilometres from Durban in KwaZulu- Natal, South Africa. Edgewood College opened in 1966 and moved to its present location in 1970. It was originally built to serve the needs of the Natal Education Department which controlled the education in the "white" schools in Natal. Prior to 1990, Edgewood students studied towards Diplomas in Education, but subsequently under an agreement with the University of Natal, degree courses in Primary Education were moved to the Edgewood campus.



In 1991, the College admitted a large cohort of Zulu students into the Primary Diploma course. This was a first step at racial integration of the student body. Subsequently, the College was opened to all racial groups and was greatly enriched by a merger with Bechet College of Education which had traditionally served the “Coloured” community.

The University also underwrites the Higher Diploma in Secondary Education. The participants in this study were studying towards the Higher Diploma in Secondary Education, which qualifies teachers to teach in the Secondary school. Students wishing to teach Mathematics are required to complete a course in Mathematics Education. Since the activities from which the empirical material was to be gathered formed part of this Mathematics Education course, (and the development of a meaningful curriculum for this course was a prime motivating factor for this study), the sample included all the Mathematics Education students in the second, third and fourth years of study. This was in a sense an “opportunity sample” since the participants were all students of a course for which I was responsible, and so I was easily able to maintain regular contact. I limited the study to students at Edgewood College of Education where I am employed since I do not have the same opportunity to work with students at other Colleges of Education.

The current curriculum of the College requires the second year students to do Mathematics Education as part of the Professional Studies course and the research was conducted within the context of this Mathematics Education component. It is intended that the subject methodology courses deal with educational issues specific to the particular subject - personal competence in the subject content and general classroom skills and principles form part of other courses. The Third and Fourth Year students followed an earlier curriculum which did not specifically include subject methodology. However it was decided within the Mathematics department that they would have one forty minute lecture period per week of Mathematics Education and this provided the opportunity and context for their data collection. However these more senior students had less lecture time available for the activities than did the Second Year students and so more work was required to be done in their own time. This did not appear to influence the quality of the data.

Although empirical material was obtained from all the Mathematics Education students, nine students were selected as focus students. This selection was based on initial responses to the research and attempted to include a range of cultural groups, gender and perceived academic ability. A further criterion was that the student should be engaged in Practice Teaching at a school that was easily accessible to the researcher to facilitate observation of classroom practice.

There were initially 54 students in the sample but several students did not continue their studies to the end of the year and so their data were excluded.

**Table 1**      **Students included in the sample**

Year of Study	Number of students at outset of course	Number of students abandoning studies	Number of students included in the sample
Second (2SC)	16	2	14
Third (3SC)	18	1	17
Fourth (4SC)	20	1	19
<b>TOTAL</b>	54	4	50

The designations, 2SC, 3SC, and 4SC refer to the year of study in which the preservice teacher is currently engaged, and the fact that they are following a course leading to secondary school teaching.

Table 2 shows that the three different year groups differed quite widely in gender and racial composition. These preservice teachers were schooled in the apartheid era and so their racial classification determined the schools they attended. The ethos and style of teaching at the different schools were not uniform and this could impact on the different beliefs held by the preservice teachers.

**Table 2** Composition of Sample in Terms of Gender, Race and Home Language

Year of Study	Male	Female	English (first language)	English (second language)	White	Indian	Coloured	Black
Second (2SC)	11	3	7	7	2	3	2	7
Third (3SC)	12	5	11	6	1	7	3	6
Fourth (4SC)	9	10	17	2	10	4	3	2
TOTAL	32	18	35	15	13	14	8	15

### 3.3 INSTRUMENTATION

"Qualitative researchers deploy a wide range of interconnected methods, hoping always to get a better fix on the subject matter at hand" (Gallagher, 1991). This view is supported by Erickson (1998) who speaks of 're-searching' being the process of seeking and seeking again, recursively. With this in mind, I designed a variety of instruments for data collection. These were learning activities designed to create an awareness of implicit personal theories of teaching and learning Mathematics, to foster a reflective consideration of the implications and consequences of such theories, and to provide opportunities and impetus for change. The learning activities were not solely for the purposes of gathering empirical material; they were also intended to "assist the teacher in moving from an implicitly held and private belief system to an explicit description of his or her cognitive frame of reference" (Clark & Peterson, 1990, p.287).

Each lecture in the course took the form of a learning activity. These learning activities typically followed a pattern of individual response, group discussion of those responses, and finally some written response from each student. These written responses form the bulk of the data. The empirical material is thus mainly specifically elicited writing or drawings. This approach is fairly structured and the possibility of leading questions exists since only questions which I, as the researcher deemed significant were specifically asked. However as Bogdan and Biklen (1992) note, "the advantage of soliciting compositions is that the researcher can have

some hand in directing the authors' focus and thereby get a number of people to write on a single event or topic" (p. 133). The number and variety of activities represents an attempt to gain multiple perspectives on the preservice teachers' thinking and confirming evidence of what might be inferred from one activity.

An overview of the methods and techniques employed to acquire the data for each of the research questions is presented in Table 3.

**Table 3 Overview of the data collection methods.**

Data collection activity	Nature of the empirical material	Question One	Question Two	Question Three	Question Four
Activity One Outcomes of a Mathematics Education course	Writing	✓			
Activity Two What would you do?	Writing		✓		
Activity Three Metaphors for the Teaching and Learning of Mathematics	Writing and drawings		✓		
Reading Activity	Writing			✓	
Teaching Activity	Researcher's observations			✓	
Student Interviews	Audiotapes and transcriptions	✓	✓	✓	✓
Teaching Practice	Researcher's observations		✓	✓	
Metaphors for the Teaching and Learning of Mathematics – (a second look)	Writing and drawings		✓		✓

Each activity will now be discussed in the context of the research question it was designed to inform. A detailed description of each activity and a copy of the actual Activity sheet given to the participants are provided in Appendices A to G.

### **3.3.1 What is the perceived role of personal theories in the professional development of preservice Mathematics teachers?**

#### *Activity One: Outcomes Of A Mathematics Education Course.*

The purpose of this free response activity was to determine whether the students perceived theories of teaching and learning Mathematics as significant in their preparation for teaching.

The activity involved participants individually suggesting possible outcomes for a Mathematics Education course, followed by an activity designed to promote discussion and ultimately ranking of all the suggested outcomes in order of importance. (See Appendix A)

This activity gave individual preservice teachers an opportunity to express their ideas in an unthreatening environment. Each participant was afforded the opportunity to think and consider his or her own ideas first. The benefit of shuffling and redistributing the slips of paper containing the desirable outcomes was that each group could consider the ideas independently of the person responsible for the idea. This prevented the ideas of dominant participants prevailing because of the strength of their personalities rather than the quality of their thinking. The condition that no more than one quarter of the outcomes could be classified vitally important required participants to be very selective and was intended to provoke discussion and debate among participants.

The completed activity sheets provided the data. The outcomes suggested by individuals could be scanned for evidence that beliefs, formal theories or personal theories were considered worthwhile outcomes of a Mathematics Education course. The language used by the participants was also indicative of underlying beliefs.

The limitation of this instrument is that it gave no direct opinion on the value of beliefs and theories other than their appearance on the preservice teachers' lists. However while it is conceivable that a participant who might place some small value on beliefs and theories would overlook this in their list of desirable outcomes, it is unlikely that these would be overlooked by a preservice teacher who considered them very important. The interpretation of this data is "beset with the typically intransigent problems that face those who would try to understand how people think from what they say" (Munby, 1986, p.206). In fact, in this case the task is further complicated by having to understand how people think from what they write, in many cases in their second language. The later interviews with selected participants provided an opportunity for clarification.

### **3.3.2 What personal beliefs about the teaching and learning of Mathematics do preservice Mathematics teachers hold?**

Two activities were designed to elicit the personal beliefs of the participants and to raise awareness of alternatives. The written responses to these Activities were supplemented in some cases with individual interviews.

#### *Activity Two: What Would You Do In This Situation?*

The purpose of this activity was firstly to encourage participants to think about how they, as teachers, might react to three critical incidents, and secondly to try and identify underlying reasons for their own ideas and for differences evident among the ideas of their fellow students (see Appendix B). Each of the three critical classroom incidents was designed to provoke thought on different issues. The incidents are all dilemmas - problematic, puzzling and calling for some immediate response on the part of the teacher.

The first critical incident, referred to as Jane's Story, was concerned with the role of the teacher as the source of mathematical knowledge and as the authority in the classroom. The responses of the participants to a situation in which they do not have the answer to a problem were indicative of how they perceived their role in the teaching and learning of Mathematics.

The second critical incident, referred to as Richie's story, related to the process of learning Mathematics and the teacher's role in facilitating this learning. The suggestions participants made for helping Richie, who had not been able to master the previous day's work and was learning at a different rate to others in the class, were indicative of how they think Mathematics is learnt.

The third critical incident, referred to as Ms Jones' story, was concerned with a teacher being criticised for facilitating a programme of independent study rather than directly teaching the work. The issue here related to the process of learning Mathematics and the teachers' role in facilitating this learning. The importance that the preservice teachers attached to individual learners making sense of the Mathematics, and their conception of learners possessing the ability to learn independently, was indicated by their responses.

The small group activity, which followed the individual responses, was designed to promote discussion and thought as to why teachers behave as they do, and consequently reflection on the beliefs that drive them personally. The completed activity sheets provided the data. Each participant provided three written responses to the situations and an account of the group opinion in relation to their own. The personal beliefs inferred from these writings could be identified and classified. The language used also indicated conceptions of learning and teaching. For example, a participant who spoke of a pupil "catching it" appeared to see Mathematics as commodity to be passed from one person to another.

Francis (1997) describes a similar Critical Incident Task that she has used with third year preservice teachers at James Cook University in Australia. The purpose of this task was to develop reflective practice and new ways of looking at the way things are. Unlike the Activity Two described above which was based on hypothetical incidents, the actual incidents for discussion in Francis' work were supplied by the student teachers themselves and drawn from their experiences in the schools. Despite this significant difference in the task, Francis' belief that "day-to-day" incidents provide an opportunity to "confront the values and beliefs that underpin our thinking, perception and action" (p.172) is surely applicable.

Limitations of this instrument for collecting data include:

- The choice of incidents may not be suitable for all participants. Francis (1997) has suggested that "the mundane and ordinary events of teaching and learning can be more illuminating than those immediately perceived to be problematic" (p.184). It is possible that the classroom incidents lay outside the experience of some participants and so their responses were not rooted in reality.
- Participants may have perceived some responses as preferred by the group and/or the lecturer and so refrained from voicing or writing alternative responses.
- The response to single isolated hypothetical incidents may not necessarily be strongly linked to a particular personal viewpoint on teaching or learning Mathematics. Responses might be influenced more strongly by cultural beliefs than educational beliefs (see page 17).
- The responses may be off the intended path as the participants follow different lines of thought. An example of this occurred in Ms Jones' Story. It was intended that the respondents comment on their personal commitment to the self-study method. However when faced with the problem of complaining parents, many of the preservice teachers made

management type suggestions such as asking the principal to call a meeting, rather than expressing their personal opinions.

I consider that a strength of using Critical Incidents as a instrument for collecting empirical material lies in the hypothetical aspect. I hoped that the preservice teachers would have automatic responses that would in a sense be from the heart and not the head because they would not have to actually deal with the problem in practice. This means that pragmatic considerations would not mask their intuitive reactions to the dilemmas.

### *Activity Three: Metaphors For The Teaching And Learning Of Mathematics*

The purpose of this activity was to give preservice teachers the opportunity to try to capture the essence of their personal theories about the teaching and learning of Mathematics in the form of a drawn and described metaphor.

The activity was carried out in three stages, the first two being preparatory exercises ahead of the main task. Firstly the idea of using metaphors to describe educational ideas was introduced by using some prepared drawings representing metaphors for teaching and learning. This was followed by an activity in which the preservice teachers were asked to draw a picture that is a metaphor for teaching and learning Mathematics as they have experienced it, either as learners or more recently during their Practice Teaching experiences. Finally the participants were given the task of drawing and explaining a metaphor to express their vision of teaching and learning Mathematics in schools. Participants were encouraged to take the Activity sheet away and to give some considerable thought to the metaphor they choose (see Appendix C).

The metaphors drawn and described by the preservice teachers provided the data from this activity. The personal theories underlying the metaphors could be inferred and classified. This classification could be done according to the categories of acquisition and participation metaphors suggested by Sfard (1998) or into the four categories suggested by Fox (1983), namely transfer, shaping, travelling and growing theories.

The use of metaphors as an aid to eliciting and understanding the personal beliefs of people is well documented as has been discussed in Chapter Two (see page 26). Because the focus of this study was personal theories (as opposed to formal theories), a method was needed that



would allow for creativity and expression of individual opinion in a non-judgmental way. I hoped that a novel task might promote original thought and so the students were asked to both draw and describe a situation that they considered to be a metaphor for the teaching and learning of Mathematics.

Although cognisant of a body of opinion supporting the use of metaphors as tools to investigate the thinking of teachers, (Munby, 1986; Miller & Fredericks, 1988), this activity was originally designed prior to finding references to drawn metaphors, or indeed to descriptions of situations specifically constructed as metaphors for a particular concept. Subsequently reference has been found to preservice teachers at James Cook University, Cairns, Australia "writing and analysing personal metaphors and translating these as "pictures"" (Francis, 1997, p.172). The metaphors used informally by participants in this study as they write or speak about Mathematics teaching and learning were not a prime source of data but may provide some confirming evidence of the beliefs suggested by their writings or oral interviews.

#### *Interviews With Focus Students*

In order to clarify issues and to give the participants an opportunity to expand on their written answers, several students were interviewed. The actual questions asked can be found in Appendix D. Participants were asked about their own school experience, and how they hoped their own teaching would emulate or differ from the teaching they had experienced at school. This was followed by a discussion of possible personal theories that led their teachers to teach in the way they did. This was an attempt to promote thought on the possible links between personal theories and practice. The preservice teachers were then shown their drawn metaphor and asked to describe it again to provide clarity and an opportunity to add to the written description. Finally, students were asked to comment on the importance that they would attach to personal theories now that awareness had been raised.

These interviews were recorded on audiotape and subsequently transcribed. The data are thus in the form of written transcripts.

### 3.3.3 Are Preservice teachers aware of the links between their personal theories and their classroom practice?

The activities designed to inform this question were developmental in nature and intended to raise the participants' awareness of the link as much as to seek evidence of the existence of this awareness.

#### *Reading Activity: Personal Conceptions Of Teaching And Learning*

This activity was based on the following article:

Fox D (1983). Personal Theories of Teaching. *Studies in Higher Education*, 8(2), 151-163.

In this article, Fox identifies four different categories of conceptions or theories of teaching. These are ideas that students and lecturers in Higher Education have expressed. These categories are expressed in metaphorical terms such as transfer theories, shaping theories, travelling theories and growing theories. Some of these would have been familiar to the participants from their previous work on personal metaphors for teaching and learning Mathematics.

Details of the activity are provided in Appendix E. The Activity firstly required the preservice teachers to study the article in order to provide an opportunity to read of some alternative ideas to their own. The writing of the summary table was simply an aid to organise this new information. The second part of this activity was designed to focus on the notion that the classroom practice of the teachers could be the result of their personal theories of teaching and learning. Acceptance of this notion would imply that it is possible to infer, at least in part, the personal theories of a teacher by observation of his or her classroom practice. The preservice teachers were given the opportunity to discuss the evidence they would consider indicative of each of the four identified personal theories. The final open questions were designed to promote thinking and to provide evidence of the idea that personal theories might underpin all of a teacher's practice. The data for this activity are the written responses of the participants.

#### *Practical Teaching Based On Particular Conceptions Of Teaching And Learning*

Once again, this activity was based on ideas found in the following article:

Fox D (1983). Personal Theories of Teaching. *Studies in Higher Education*, 8(2), 151-163. In addition to the article, a summary table of the different theories prepared by Fox and appended

to his article was made available to the preservice teachers. Each small group was allocated a Mathematics topic taught in the secondary school and asked to prepare a presentation outlining a teaching sequence and approach to the topic that the group felt would be typical of a teacher with that particular personal theory of teaching (see Appendix F).

The data from this activity were informal written observations of the teaching done by the small groups. The purpose of this activity was to establish the link between personal theories and classroom practice in a practical way.

### *Observation Of Classroom Practice During Practice Teaching*

We cannot learn what someone's theory-in-use is simply by asking him. We must construct his theory -in-use from observations of his behaviour. (Argyris & Schön, 1974, p.7)

All the students participating in this study spent five weeks teaching in a secondary school of their choice. Their teaching time at the school was divided between Mathematics and their other major subject specialisation. This meant that most of the preservice teachers taught Mathematics to two or three different classes. This provided an opportunity to test their metaphors and personal theories and to engage in reflective practice.

The timing of this Teaching Practice period fitted in with the sequence suggested by Tann.

I have suggested so far that reflective practice requires the practitioner to elicit and identify their personal theories, to explore these by examining their rationale, by problematizing and looking for alternative analyses, then to compare these with peers and with public theories before attempting to reformulate the theory and test it against further practice. The typical context for this is classroom fieldwork. (Tann, 1993, p. 56)

Staff members from Edgewood College of Education were required to tutor and assess the students in the schools. Each member of the tutoring team was responsible for about fifteen preservice teachers spread through six or seven schools. Access to the schools was not always easy – many of the schools were in areas regarded as high risk for crime and car hijacking and so tutors had to travel in teams on specified days. This reduced the time that was available to visit the students in their schools.

Before the Practice Teaching period began, all the preservice teachers were given a page of requirements from the Mathematics department. Among other things, this called for some reflective writing in the form of a journal or post-lesson reflections. It is also requested that the

participants in this study keep in mind their personal metaphor for the teaching and learning of Mathematics – possibly even to the extent of keeping a copy in their lesson preparation book.

The empirical material collected from observation of the preservice teachers in the classroom were copies of the lesson evaluation notes given to the student after the lesson, and the researcher's fieldnotes and observations. There were many constraints on the collection of this empirical material and reasons to question its validity.

- The workload of each tutoring College lecturer was heavy. This resulted in very rushed visits to the schools with little time to talk to the preservice teachers. This made it difficult to really discern the thinking behind the teaching.
- The teaching behaviour of the student teachers was influenced by the presence of a tutor in the classroom and cannot be inferred to be typical of that person.
- Many novice teachers experience great difficulty with classroom management and discipline. They are very nervous and fearful of losing control and they see the risk of this happening if they try any teaching style other than direct teaching and very closely supervised classwork. What was observed could be as much a strategic survival strategy as an expression of an implicit theory about the teaching and learning of Mathematics. This phenomenon was also observed in a study among teachers in Brazil where Jofili and Watts (1995) found teachers to be “insecure in changing their classroom practice because they feel frightened of losing class control” (p.219).
- The preservice teachers were guests in the schools and subjected to the prevailing ethos and practice of the Mathematics department at the school. Some schools were very prescriptive and the student teachers were given the teaching materials and a detailed programme of work that left little room for personal expression.
- I was only able to visit a limited number of the participants in the study, so the data obtained was limited to about one third of the participants.

As a result of the factors listed above, I did not consider that the data from the teaching practice period would contribute significantly to this study and so it was not included.

### **3.3.4 Do preservice teachers view their personal theories as developing or complete?**

#### *Activity - Metaphors For Teaching And Learning Mathematics (a second look)*

This activity provided an opportunity for the preservice teachers to reconsider their original metaphors for teaching and learning Mathematics and to draw and describe a reconsidered metaphor if they had changed their personal theory in any way (see Appendix G). This activity was done in the lectures immediately following the Teaching Practice period during which it was hoped the participants' ideas and personal theories had been tried and tested. The empirical material generated by this activity is the written responses of the preservice teachers to the questions, and possibly a new or amended drawn and described metaphor.

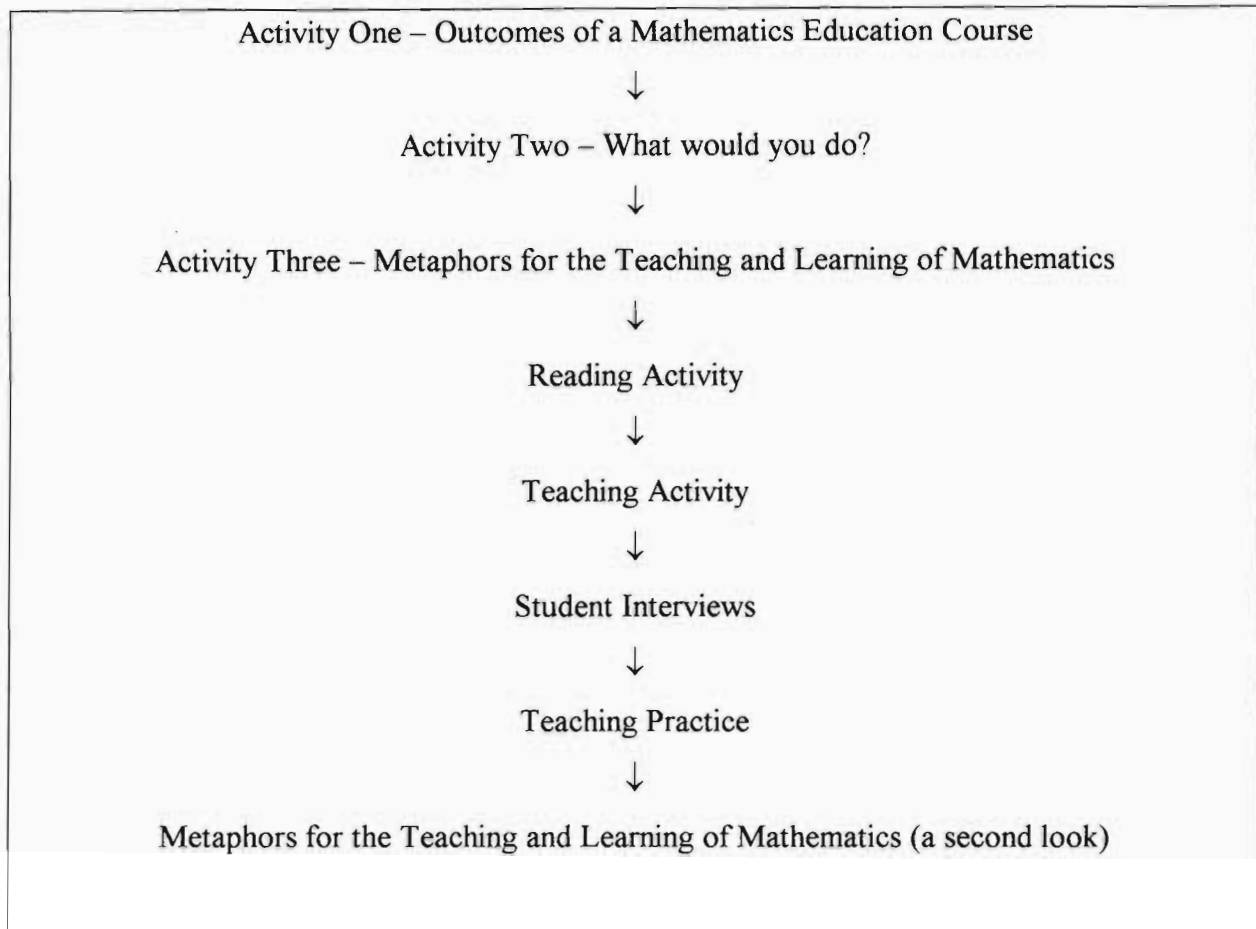
### **3.4 PROCEDURES FOR THE COLLECTION OF EMPIRICAL MATERIAL.**

The data was collected throughout the academic year so that any changes in thinking would be evident. The activities were designed to be completed in a specific order. The reason for this was to delay the introduction of the ideas of formal educationists until after the preservice teachers had committed their own ideas to paper. This made it more likely that a personal theory would be forthcoming – possibly a description of implicitly held beliefs. It was considered that the influence of the formal theories of educationists might overshadow the participants' personal theories.

The limited time available for the Mathematics Education course (only one lecture per week), led to the activities being done at best at weekly intervals, but often further apart due to interruptions in the lecture programme due to examinations, public holidays and the like. This definitely led to a lack of continuity and difficulties in sustaining a line of thought. This was further exacerbated by student absenteeism. Interviews with individual students were conducted outside of the Mathematics Education time, usually by arrangement with the other Mathematics lecturers.

#### **3.4.1 Sequencing of Activities**

The sequencing of activities is outlined in the following figure.



**Figure 1** Sequence of Activities

### 3.4.2 Ethical Considerations

A study of people's thinking and the subsequent possibility of this thinking being at best commented upon and at worst blatantly criticised gives rise to some ethical considerations. The researchers stand to benefit through academic recognition of their work, but what of the participants in the research study? What is in it for them?

I subscribe to the ethical position described by Denzin and Lincoln (1994) as the contextualised-consequential model. This model builds on principles of mutual respect, noncoercion and nonmanipulation, the support of democratic values and institutions, and the belief that every research act implies moral and ethical decisions that are contextual. In practice this would mean that participants should not be deceived about the nature or purpose of the study and possible consequences of their participation or non-participation.

The activities from which the data was derived were all part of a Mathematics Education course and their primary purpose was the professional development of the preservice teachers. The fact that the activities could provide empirical material for this study was secondary. The preservice teachers' participation in the activities was not voluntary in the sense that this work contributed to their final Mathematics assessment. They however did have the option to allow their work to form part of this study or not. I thought it important that they viewed their participation in the activities as part of their professional development and not as a personal favour to me. I was concerned that the latter viewpoint would lead to stock responses and impaired consideration of the issues. Consequently it was only after the bulk of the empirical material had been collected that the research project was mentioned and the students asked if they would object to their data being used in the study. A copy of the consent form is included in Appendix H. Confidentiality was assured by assigning each student a pseudonym.

Students who did not wish their work to be included were invited to communicate this to me, whereupon their work would have been removed from the sample. No student took this option.

## CHAPTER 4

## ANALYSIS AND RESULTS

The data collection was achieved through the activities described in Chapter 3. The time scale for this data collection is indicated in Table 4.

**Table 4** Time scale for data collection

Data collection activity	2 SC GROUP	3 SC GROUP	4 SC GROUP
<b>Activity One</b> Outcomes of a Mathematics Education course	24 February	20 February	2 March
<b>Activity Two</b> What would you do?	3 March	27 February	9 March
<b>Activity Three</b> Metaphors for the Teaching and Learning of Mathematics	10 March	13 March	16 March
Reading Activity	24 March	27 March	30 March
EASTER HOLIDAYS			
Teaching Activity	21 April – 5 May	17 April – 8 May	20 April – 11 May
FIRST SEMESTER EXAMINATIONS			
Student Interviews	Conducted between 15 June and 23 June		
JULY HOLIDAYS			
Teaching Practice	21 July – 21 August		
POST TEACHING PRACTICE BREAK			
Metaphors for the Teaching and Learning of Mathematics – (a second look)	1 September	4 September	7 September

A section in this chapter is devoted to each of the four research questions that underpin this study. In each case, an assertion is made in answer to the question and then supporting and counter evidence is provided and discussed.

#### 4.1 WE NEED PROPER MATHS EDUCATION - NOT ART!

This section deals with the empirical material related to Research Question One:

**What is the perceived role of personal theories in the professional development of preservice Mathematics teachers?**



**Assertion One**

Preservice Mathematics teachers do not intuitively perceive consideration of personal theories of teaching and learning Mathematics as an important component of a Mathematics Education course.

This material was mainly derived from Activity One, which was described in Section 3.3.1. Following Activity One, the individual responses of the preservice teachers were classified into the four aspects of a Mathematics Education curriculum suggested by Manouchehri (1997). The four aspects are subject content knowledge, pedagogical content knowledge, pedagogical reasoning (which I expanded to include general classroom skills) and beliefs (see page 12 for a more detailed discussion of these aspects).

The indicators used for classification of the outcomes suggested by the participants in the study are summarised below. This table was used to allocate each suggested outcome to one of four categories.

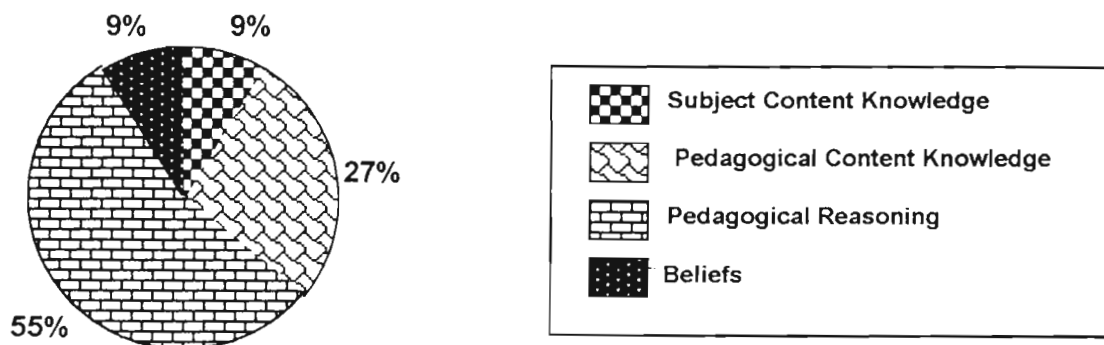
**Table 5 Indicators for the classification of outcomes for a Mathematics Education course**

Category	General description of related outcomes
Subject Content Knowledge	<ul style="list-style-type: none"> <li>• knowing Mathematics</li> <li>• personal mathematical competence</li> </ul>
Pedagogical Content Knowledge	<ul style="list-style-type: none"> <li>• knowing the <b>school</b> Mathematics</li> <li>• ways of teaching and explaining <b>school</b> Mathematics.</li> </ul>
Pedagogical Reasoning	<ul style="list-style-type: none"> <li>• skills and insights related to creating a good learning environment (not specifically related to Mathematics teaching).</li> </ul>
Beliefs	<ul style="list-style-type: none"> <li>• personal theories or formal theories</li> <li>• any outcome related to personal development, personal values or belief systems.</li> </ul>

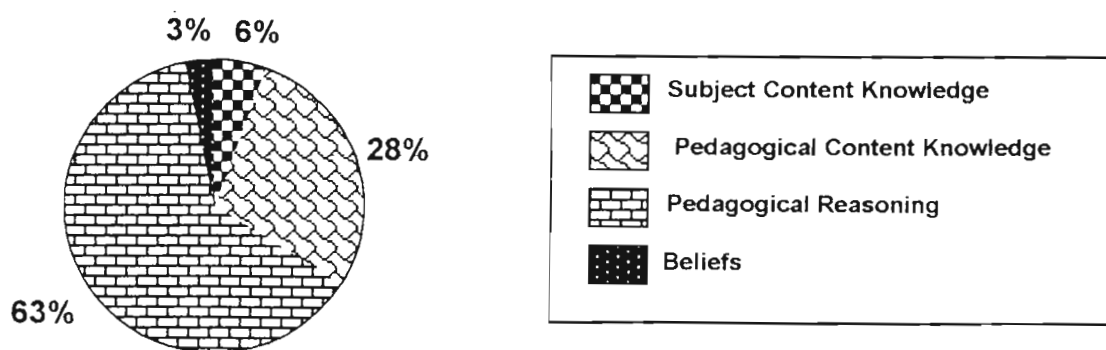
Although the activity requires each participant to suggest five possible outcomes for a Mathematics Education course, some of the preservice teachers were not able to think of that number. The spread of suggested outcomes over the four foci suggested by Manouchehri (1997) is tabulated below.

**Table 6: Desired Outcomes of a Mathematics Education Course**

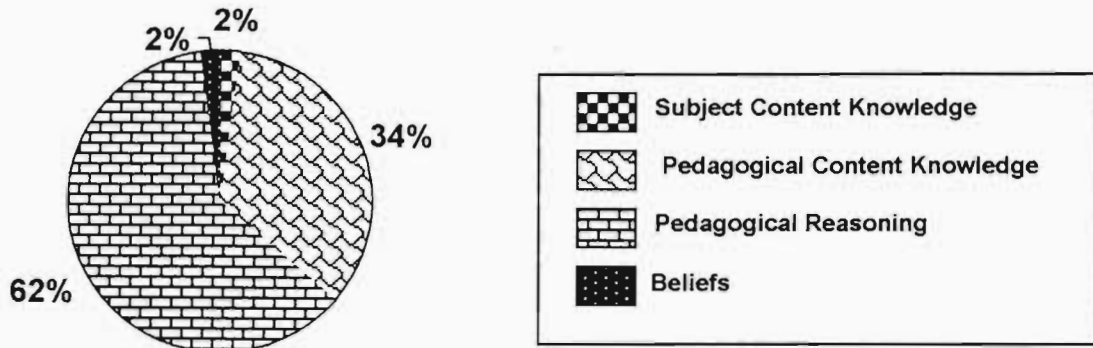
	Subject Content Knowledge	Pedagogical Content Knowledge	Pedagogical Reasoning	Beliefs	Total number of responses
Second Years	5	15	31	5	56
Third Years	4	19	43	2	68
Fourth Years	2	29	53	2	86
	11	63	127	9	210



**Figure 2** Graphical representation of the distribution of outcomes for a Mathematics Education course suggested by preservice teachers in the second year of study.



**Figure 3** Graphical representation of the distribution of outcomes for a Mathematics Education course suggested by preservice teachers in the third year of study.



**Figure 4** Graphical representation of the distribution of outcomes for a Mathematics Education course suggested by preservice teachers in the fourth year of study.

Overall, 60,5% of the outcomes suggested by the preservice teachers fell into the category of Pedagogical Reasoning and were mainly related to day to day classroom management issues rather than reflective classroom practice. I would classify these outcomes as classroom skills. Some examples of such outcomes suggested by the preservice teachers are reproduced below.

*To be able to create good pupil activities for lessons (Debbie 4SC)*

*Learn the skill of being well prepared and organised (Gwen 4SC)*

*To be able to discipline the class (Kate 3SC)*

*To be able to arrange the class in groups and keep discipline (Bryan 2SC)*

*To learn communication skills (Zabeer 3 SC)*

The next largest category was that of Pedagogical Content Knowledge which featured in 30% of the responses. Responses in this category were typically of the nature of "tips for teachers" and are largely knowledge type outcomes. The following are some typical examples.

*Methods of remembering theorems, formulas etc. (Roy 4 SC)*

*Specific teaching methods on various maths topics (Ken 4 SC)*

*To teach Maths graph work effectively (Lee 3SC)*

*I would like to know how to teach Geometry (Sifiso 2 SC)*

There was little interest expressed in subject content knowledge, a mere 5,2% of the total responses, mainly because the Mathematics Education course runs parallel with an academic Mathematics course through which preservice teachers can reasonably expect to develop their own personal mathematical competence. The following responses fell into this category.

*I would like to understand logarithms well (Lameck 2 SC)*

*Acquire a better understanding of Mathematics (Sameer 2SC)*

*Being an expert in Mathematics (John 3SC)*

*I would get a sound understanding of Maths (Vusi 3SC)*

There were very few responses related to personal values and the development of attitudes and beliefs – only 4% of the total responses. These were mainly related to desirable personal qualities for teaching such as patience and tolerance.

*Ability to be patient and understanding (Sachin 4SC)*

*I must to some extent be convinced that Maths is not a difficult subject (Mike 3SC)*

*Creativity (Trent 2SC)*

There was no marked difference in the responses from the various year groups. A slight decrease in emphasis on subject content knowledge is noted among the more senior students.

The graphical representations as shown in Figure 2, Figure 3 and Figure 4 make it clear that the preservice teachers saw the Mathematics Education course mainly as an opportunity to develop their classroom skills. This prompted my assertion that they had no intuitive feeling that their own personal theories, nor indeed the formal theories of educationists, were fruitful areas for study.

Somewhere along the line, there is a complete mismatch between the outcomes for the course valued by some students and the outcomes valued by myself as the lecturer. This is well expressed by the heading for this section! In the inadequate time “stolen” from the academic Mathematics course, there is no question of spending time on general classroom skills. Unfortunately, it seems that all academic departments share this view and so preservice teachers are not given extensive help in these areas.

I had suspected that theoretical considerations would not be popular with the preservice teachers as they tend to see them as unrelated to real life in the classroom. One of the activities designed to raise awareness of the link between personal theories and classroom practice, (see Appendix F), was set in the context of several topic areas from the school Mathematics syllabus. This was intended to incidentally achieve some of the pedagogical content knowledge outcomes and to put the theories in a real world context.

During the interview I asked the preservice teachers whether they now saw the value of discussing personal theories. The responses include:

*It was good to do a metaphor and lay bare your visions of what you should teach. I think it was good. (Mangiso 2SC)*

*I think this is good because essentially you can teach whatever you want to teach us, but when we get out there, you won't be there and we have to know for ourselves how we are going to teach. In a way you have been teaching us in this way, you've been letting us try to figure out what is best for us. It was also good to discuss all the different views and learn from each other. (Marc 4SC)*

*You had an idea at the back of your mind about how you would like to teach and things like that, but it was never anything put on paper - like this is my belief, this is how I would like to teach. Whether it will happen like this we still don't know, but at least you've put down on paper and the fact that I am going to have this with me - you can go home every night and reiterate yourself by saying "right, this is the way I want to do it, how am I going to approach my lesson?" (Penny 4SC)*

*I think your metaphor puts you on track and gives you a goal as a teacher. It also gives you a rating scale to judge your lessons. (Steve 3SC)*

These positive responses to the interview question were not general. The title of this chapter is drawn from an informal Graffiti Wall set up for students to express their feelings about the Teaching Practice period. This comprised sheets of paper pinned on a notice board, with several focus phrases, such as "I was impressed by..", "I was disappointed by..." already in place. The preservice teachers created a dialogue of comments and responses over a period of a few weeks. Comments relevant to this study included:

*I would suggest that Maths education prepares us for teaching in the REAL WORLD! (Anonymous 4SC)*

*The College did not prepare us adequately for Prac teaching. Needs to be proper Maths Education not ART! (Anonymous 4SC)*

There seemed to be a blurring in the preservice teachers' minds between a personal theory of teaching and learning and a teaching strategy.

*I think we saw the different types of teaching, some people do teach the shaping theory, some do teach the growing theory and you discover the difference between them and choose one you think is relevant to the maths. (Andre 2SC)*

There is certainly no common shared vision between students and lecturer as to the content of the Mathematics Education course. This could be construed as problematic and in conflict with the spirit of the course.

#### **4.2 - "...AND AT THE END OF IT, KNOWLEDGE IS TRANSFERRED TO THE STUDENT"**

This section is concerned with the personal theories of preservice teachers as elicited and inferred from their responses to common teaching dilemmas, drawn and described metaphors for the teaching and learning of Mathematics, observation of their classroom practice and interviews. This information was sought in response to the following research question:

**What personal beliefs about the teaching and learning of Mathematics do preservice Mathematics teachers hold?**

##### **Assertion Two**

The personal theories of teaching and learning Mathematics held by preservice Mathematics are typically of an acquisition or transfer nature.

The data relating to the personal theories of the preservice teachers was analysed using a phenomenographic method which aimed "to reveal the qualitatively different ways in which people experience and conceptualise various phenomena in the world around them." (Marton et al., 1993). The emphasis was thus on the discussion and classification of ideas rather than people. This was intended to reveal themes in the thinking of the whole group of students. Important factors to be considered in the teaching/learning situation are the teacher, the learner, the subject matter and the relationships between those factors. The data was classified initially according to the four conceptions of teaching suggested by Fox (1983). The link between these four conceptions and the participation and acquisition categories suggested by Sfard (1998), and the six conceptions of learning suggested by Marton et al. (1993) has been

explored (see page 18). Fox (1983) appends to his article a summary sheet, which is designed to highlight the distinguishing features of each of the theories of teaching. I have borrowed heavily from this summary in construction of Table A1 which can be found in Appendix G.

The first source of empirical material used to answer this question was obtained from responses to Activity Two (see page 45).

#### 4.2.1 Activity Two - WHAT WOULD YOU DO IN THIS SITUATION?

This activity comprised three critical incidents, presented in story form. The responses to each story are discussed below.

##### *Jane's Story*

Refer to Appendix B, for the details of this story. I expected the responses to the dilemma of being unable to solve a mathematical problem set for the class to lie along a continuum from immediately conceding that difficulty is being experienced with the problem, through a series of avoidance or delaying strategies, to adopting a strategy that will conceal this difficulty from the learners. The following three categories of response were noted:

1. Immediately admit to an inability to do the problem.
2. Engage in a variety of delaying tactics in order to mask the inability to do the problem, but prepared to eventually admit failure if necessary.
3. Employ a variety of strategies to ensure that the learners will never know that the teacher was unable to do the problem.

The spread of responses among the participants is shown in the following table.

**Table 7 Responses to Jane's Story**

	Category One ADMIT	Category Two DELAY → ADMIT	Category Three NEVER ADMIT
Second Years	3 (21%)	5 (36%)	6 (43%)
Third Years	2 (13%)	10 (62%)	4 (26%)
Fourth Years	6 (33%)	7 (39%)	5 (28%)
TOTAL	11 (23%)	22 (46%)	15 (31%)

The categorisation of the personal theories of teaching and learning Mathematics that informed the responses to the dilemma described above was more complex. The following reasoning was applied:

Category One: The 23% of Preservice teachers who would immediately disclose to learners that they were unable to do a problem seem to view themselves as co-learners and to regard their teaching as an exploration of the subject matter. This suggests a travelling theory-in-use. A response in this category from each year group is provided below.

*Always be honest with them because you want them to be honest with you, and also they will realise that you are trying to fool them, and they will not trust you. (Andre 2SC)*

*Many people believe teachers should have a complete, comprehensive knowledge of the subject they are teaching. I do not agree with this, teachers can't know everything and they certainly do make mistakes. (Claire 3SC)*

*If nobody has a solution then openly admit that you could not find the solution but share how far you have got in the attempt to find a solution – this may help others to find the solution. (Sachin 4SC)*

Category Two: Most responses in this category described a teacher initially engaging the learners in discussion, or initiating small group discussions, or even individual problem solving attempts. Such responses seem to indicate a travelling theory-in-use. However this was used in order to find out the answer so that the teacher could be in a position to explain to the class which implies a transfer theory-in-use. A new category thus arose, namely travelling→transfer theory. Almost half the responses fell into this category which is well captured by the following quotation.

*If all else fails, I would have to admit to my pupils that as teachers we are involved in the learning process as well, and don't necessarily have all the solutions to all the problems brought forward. (Kajal 3SC)*

Category Three : Preservice teachers who feel threatened by disclosure of their inability to do a problem probably view themselves as the source of knowledge in the classroom. This would indicate an adherence to the transfer or shaping theory of teaching. 31% of the responses fell into this category. Some such responses are reproduced below.

*On my behalf, after trying the problem with the class I will tell them that we can't do it then suggest that there is a misprint. (Bryan 2SC)*

*If you tell them that you are a human being, you can also make mistakes, many problems may arise from that. For instance, they'll gossip about you, tell their*



*parents that you cram what you are teaching. I would not let them know because they would be discouraged if they see their leader is failing. (Nozipho 2SC)*

*Children see the teachers as their role models; we must not let them down. (Sipho 2SC)*

*By confessing your inability to do a particular problem, I feel that a teacher will be belittling themselves by doing this, as well as belittling the learners' confidence in the section of the work and the teacher. (Lameck 2SC)*

*I said I wouldn't tell the student that I don't know the answer because the children will not trust me anymore. (Siyabonga 3SC)*

*I would not want students to view me as a teacher who lacks knowledge in his subject. (Adrian 3SC)*

*I would never tell my pupils that I do not know the answer. I personally feel that if you let on that you don't know, the pupils will not look up to you the way they did in the past. (Nisha 3SC)*

*We all agree that we won't confess to the class. This is due to the perception that the pupils might lose respect and look down upon you. (Mike 3SC)*

*We lead the pupils to believe that we know the answer rather than admitting failure. (Zabeer 3SC)*

*But do I really want them to think I am teaching something I don't know? (Roy 4SC)*

*My response is different with some of the members of the group because some of the people are honest in such a way that they even not see when they lose their dignity or status from other people. (Edward 4SC)*

Participants in the study were asked to account for the differences evident in the responses of the members of their group. Very few people attempted this. I thought the following response very insightful.

*It is probably related to the different attitudes and values that different people have. With some people honesty is a priority and others have "perfect image" as a priority. (Lee 3SC)*

### *Richie's Story*

Refer to Appendix B for the details of this story. The dilemma in this case is the question of whether to press on with the planned activity for the day when it is apparent that at least one learner has failed to make sense of the previous day's work, or to make alternative arrangements for the lesson.

I expected responses to vary from assisting the individual learners with personal sense making activities so that they could attain competence and confidence before proceeding to the new ideas at one extreme, to reteaching the previous section to the whole class at the other extreme. (It was not anticipated that participants in this study would suggest ignoring the learner's problem and going on regardless!)

I found it useful to consider typical responses to be anticipated from teachers having the four different theories-in-use. These were constructed through consideration of the summary Table A1 which is found in Appendix G.

**Table 8 Indicators to theories-in-use for Richie's story**

THEORY-IN-USE	INDICATORS
TRANSFER	Re-explain the work. Go over it again.
SHAPING	Provide the learners with instructions as to the procedure that they should follow. Go over the steps.
TRAVELLING	Allow the learner to speak about the work, explore the problem, and try other methods and approaches.
GROWING	Help the learner as a person to achieve. Affirm him and encourage his personal mathematical development by providing individualised activities.

The participant responses were divided as far as possible into the four categories above.

Responses that did not fit clearly into one of the identified categories were scrutinised to check for further categories.

On examining the preservice teacher's responses, it again became evident that a fifth category was present. This was the same blend of the travelling and transfer theories. Many respondents seemed to indicate a willingness to flirt with the travelling theory-in-use but remain committed to the transfer theory. This was indicated by suggestions of allowing learners opportunities to discuss and explore the Mathematics, but always with the implicit proviso that the teacher would eventually explain it to the class. This hybrid theory was distinct enough to stand alone. The quantitative analysis of the distribution of the responses among the five categories is found on page 75.

Some sample responses were :

*If they (the answers) differ, then we will discuss and explain them. Even if they don't*

*differ, we will explain them once again. (Sipho 2SC)*

*Now that Richie has done the homework incorrectly, it is my duty to explain the section to him again. (Shaal 3SC)*

*Make sure that all get into the methods, and as soon as they get into them and can apply them you can introduce the Tuesday's lesson. (John 3SC)*

*I would obviously have to reteach the section with more detailed explanations. (Kajal 3SC)*

*Go through his (Richie's) work carefully explaining each and every step. (Mandla 3SC)*

*There could be only two reasons as to why he got the work wrong. The first being he maybe did not pay any attention to the work when it was taught or maybe he did not understand the approach or method that I taught. (Zabeer 3SC)*

*Explain step by step as to where he went wrong and set him straight with the brief review you planned for the day. (Sachin 4SC)*

*I would then recap the principles and do further examples to make sure that all of the class now has an understanding. (Ken 4SC)*

*They all made sure that by the end of the lesson Richie would either click on or just never know the section. (Gail 4SC)*

*You've given the basics to Richie, now it's for him to learn on his own. (Lauren 4SC)*

### *Ms Jones' Story*

Refer to Appendix B for the details of this story. This incident originates in a situation in which learners were engaged in a self-study project that is an activity typical of a travelling theory-in-use. The respondents were faced with a choice to defend this activity or to accede to requests to resume a transfer type teaching. This differs from Richie's Story, which originated in a situation in which the Mathematics was initially directly taught in the style of the shaping or transfer theories. As with the previous critical incident, the participant responses were divided as far as possible into the four categories previously discussed. Following the emergence of the travelling→transfer theory-in-use from the critical incidents discussed above, the indicators for this theory were included in the table of possible response categories. I generated these indicators by applying the characteristics in Table A1 to the situation.

**Table 9 : Indicators to theories-in-use for Ms Jones' story**

THEORY-IN-USE	INDICATORS
TRANSFER	Abandon the self-study programme and revert to direct teaching.
SHAPING	Subvert or abandon the self-study programme and provide the learners with instructions as to the procedure that they should follow. Go over the steps.
TRAVELLING	Support the self-study programme and encourage parents to accept the importance of pupils taking responsibility for their own learning and personal investigation of the topic.
GROWING	Advocate the self-study programme as an aid in the personal development of the learner and a step towards independent learning.
TRAVELLING →TRANSFER	Support the self-study programme idea but have a clear intention of explaining the work in due course.

The intended focus of this dilemma was not evident to many students who rather concentrated on issues of managing complaints from parents. The responses in this category were mainly disclaimers, suggestions for placating the parents and passing the buck. Such responses were not helpful in indicating the personal theory about teaching and learning Mathematics.

*My response was similar to the others. We all agreed that the method used was given by the department and we were following instructions. (Avanti 2SC)*

*As this was introduced by the HOD, firstly I will take this letter to him; it is then his responsibility to see whether this programme can be changed. (Daniel 4SC)*

*Realising the situation that has dawned, I would remove the self-study programme and confront the students so as to discover how much they have self discovered in the programme. From the little/quite much that they probably have discovered for themselves, I would correct any wrong concepts that have been grasped and explain the uncertain sections of the work. (Lameck 2SC)*

*I feel that it is primarily the teacher's job to explain the work to the class, because I feel that it is not good to take things for granted that pupils will self discover things efficiently for themselves. (Lameck 2SC)*

*Then you should have to see that the method enforced to pupils is of little value to the pupils, because they achieve nothing, then change it with the help of the HOD, because the main aim is to get the pupils going. (John 3SC)*

A mistrust in the ability of learners to take responsibility for their own learning, or possibly an unwillingness to relinquish control over the learning in the classroom might be a factor prompting the suggestions that the teacher should ultimately explain the work to the learners.

*I would take it upon myself to explain sections which the students find the most difficult so as to help them with their self-study programme. (Adrian 3SC)*

*I would explain to the concerned parents that self-study is part of the new age education programme and that a lot of explanations are given. (Kajal 3SC)*

*Because after pupils attempt the questions on their own, I would work with the class to solve problems. (Shaal 3SC)*

*I'd also tell them that I'd consolidate after the self-study. (Seema 4SC)*

The following response reflects the opposite process – first transfer the knowledge and then provide an opportunity to explore the subject. It seems that the spirit of a self-study assignment is not well understood.

*I would start explaining the problems to the pupils and ask them if they understand what is going on. I would then give them the self-study assignment to attempt it themselves. (Sameer 2SC)*

*The pupils need not worry, when I check the answers to the study guides, problems and strategies will be exposed. (Roy 4SC)*

Some of the preservice teachers felt that they were responsible for the learning of the pupils and would be held to account should the results not be satisfactory to the parents.

*I could in fact change the system whereby pupils have to complete tasks alone, without informing the department. Because at the end of the year pupils will fail. I will be blamed alone. (Sifiso 2SC)*

The next and prime source of empirical material used to support Assertion Two, namely that preservice teachers have simple acquisition type personal theories about teaching and learning Mathematics, was the responses to Activity Three and the subsequent interviews with selected participants.

#### **4.2.2 Activity Three – METAPHORS FOR THE TEACHING AND LEARNING OF MATHEMATICS**

The summary Table A1 (see Appendix G) was used as an aid to classify the metaphors drawn and described by the preservice teachers. The responses were not always well reasoned and in some cases seemed to be really muddled, incoherent or inconsistent. If the metaphor suggested was not coherent, no attempt was made at classification. An example of this was the metaphor suggested by Lee (3SC) who drew a farmer scattering seeds over a garden. She explained the metaphor as follows:

*The farmer plants seedlings into the ground and nourishes them until they grow into fruit trees. The farmer is the teacher, the seeds the maths knowledge and the plants are the learners. (Lee 3SC)*

The “maths knowledge” clearly cannot be transformed into learners! This preservice teacher was not interviewed and so clarification was not available.

A small number of preservice teachers missed the point of the activity and drew a non-metaphorical representation of their idea of a good learning environment. These were also excluded from the analysis.

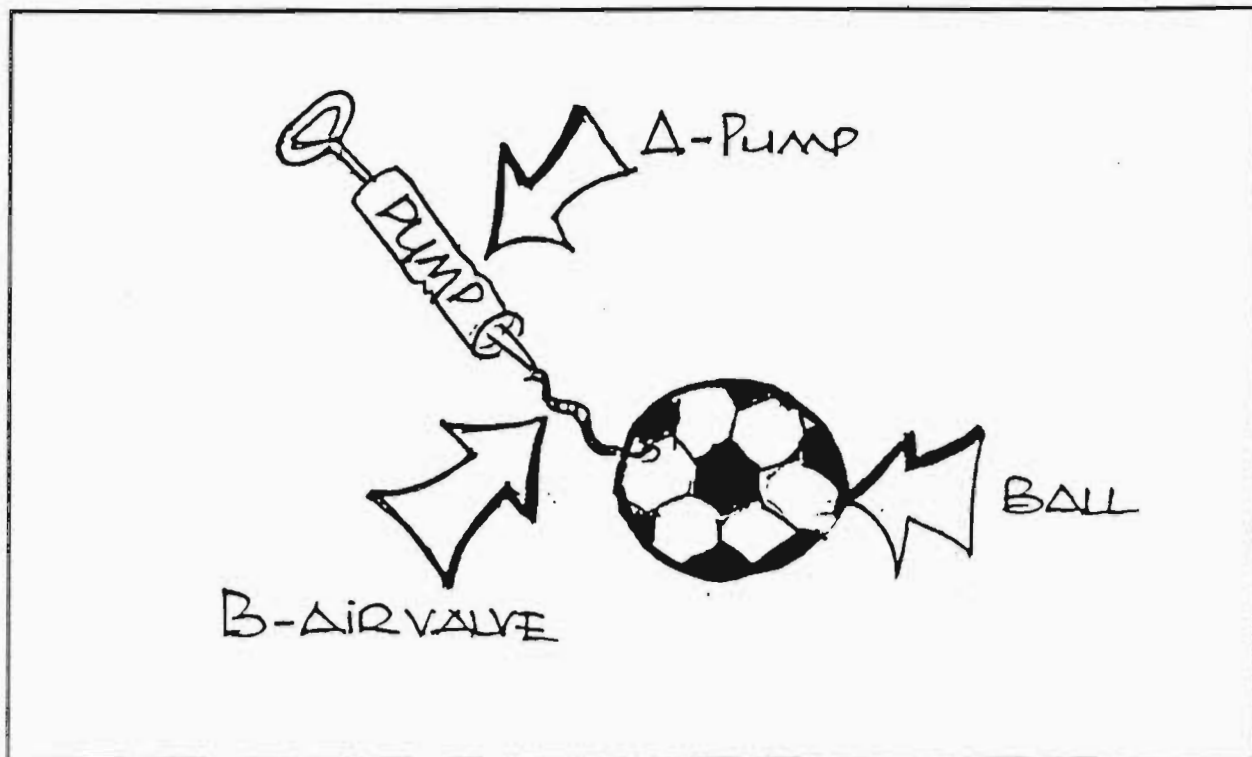
It was often difficult to decide which, if any of Fox’s four personal conceptions of teaching could be inferred from the metaphor drawn and described. It was generally easier to classify the metaphors as participation type metaphors, or acquisition type metaphors. Thereafter, a judgement as to whether the pupil or the subject was being taught was often sufficient to complete the classification. Every effort was made to be consistent across the year groups. The general results of the classification are presented in Table 10 below.

**Table 10**      **Classification of Initial Metaphors suggested by Preservice Mathematics Teachers**

	ACQUISITION METAPHORS		PARTICIPATION METAPHORS	
	SIMPLE THEORIES		DEVELOPED THEORIES	
Theory-in-use	Transfer	Shaping	Travelling	Growing
Second Year students	6	2	2	0
Third Year students	8	4	0	0
Fourth Year students	9	2	0	1
Overall	23	8	2	1

Some particular responses typical of each category follow. Where possible, interview data is included to clarify the participant’s thinking. It must however be noted that the interviews were conducted about three months after the initial metaphors were drawn, and after the preservice teachers had been exposed to the four theories suggested by Fox (1983). It is thus conceivable that the participants’ thinking had changed and so their clarifications might in fact be amendments.

## Transfer Theory



**Figure 5** Steve's Vision of the Way Things Ought to Be.

Explanation.

*A - PUMP. The pump represents the teacher*

*B - AIR VALVE. The air valve represents the channel for the air which is the mathematical knowledge to pass through.*

*C - Ball. Represents the learner who obtains the mathematical knowledge*

*Maths is learnt by the teacher pumping air (maths knowledge) into the ball which is the learner.*

During the interview, Steve was asked to explain his metaphor again. He enthusiastically did so as follows:

*I saw the pump as the teacher. I say this because she would have obtained enough Mathematical knowledge to actually impart. Why I viewed her as a pump is because she has this content, she has this system where she is able to give via the pump. She is able to pump all the content she has, not basically transferring them, but using the valve, using methods, and I saw the valve as being the channel. Using different types of methods of imparting this knowledge into the pupil which was the ball.*

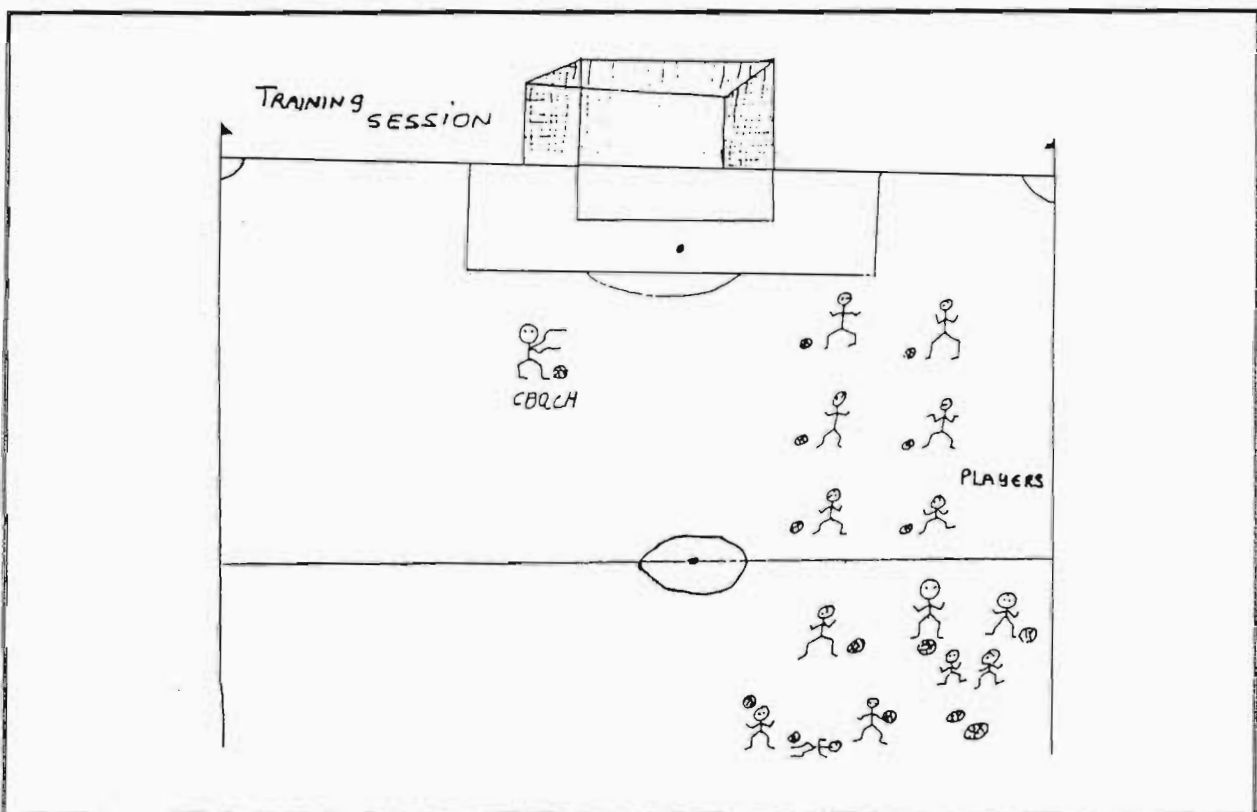
*The pupil doesn't have all the content that the teacher has but the moment she imparts it, the moment she starts putting into the ball it enlarges and the content and their knowledge of the subject increases.*

I then asked Steve if the ball could be pumped up by any other means. He replied that he didn't think so and after some thought conceded that this total dependence on the teacher was a weakness in his metaphor. After being asked if he wanted to be a "pump" during his period of Practice Teaching, Steve replied:

*Not really, looking at it now. No, I don't like this anymore. I see a problem with this. I wouldn't go out and be the pump, but merely be a catalyst to what the pupil can actually pick up from people around them.*

When given the opportunity later, Steve actually amended his original metaphor to accommodate this change in his thinking.

### *Shaping Theory*



**Figure 6 Siphon's Vision of the Way Things Ought to Be**

Explanation.

*The coach could be the teacher and the players could be learners. All the instructions he is giving to the players could be the knowledge. The first six players are running with their balls on their left feet and they are in pairs. Other players at the back are scattered. Others are talking, others enjoying. Some do not even know what to do. Others are leaving their balls behind them. The teacher/coach is concentrating more on the first six players and is happy with them. He is leaving other players at the back. But at the end, he would like all of them to play as a team and win. The teacher does not concentrate on slow learners but at the end he wants all the learners to pass. He also expects to be praised by letting all the learners to pass.*



*Finally how can this be achieved if the teacher does not treat the learners according to their abilities?*

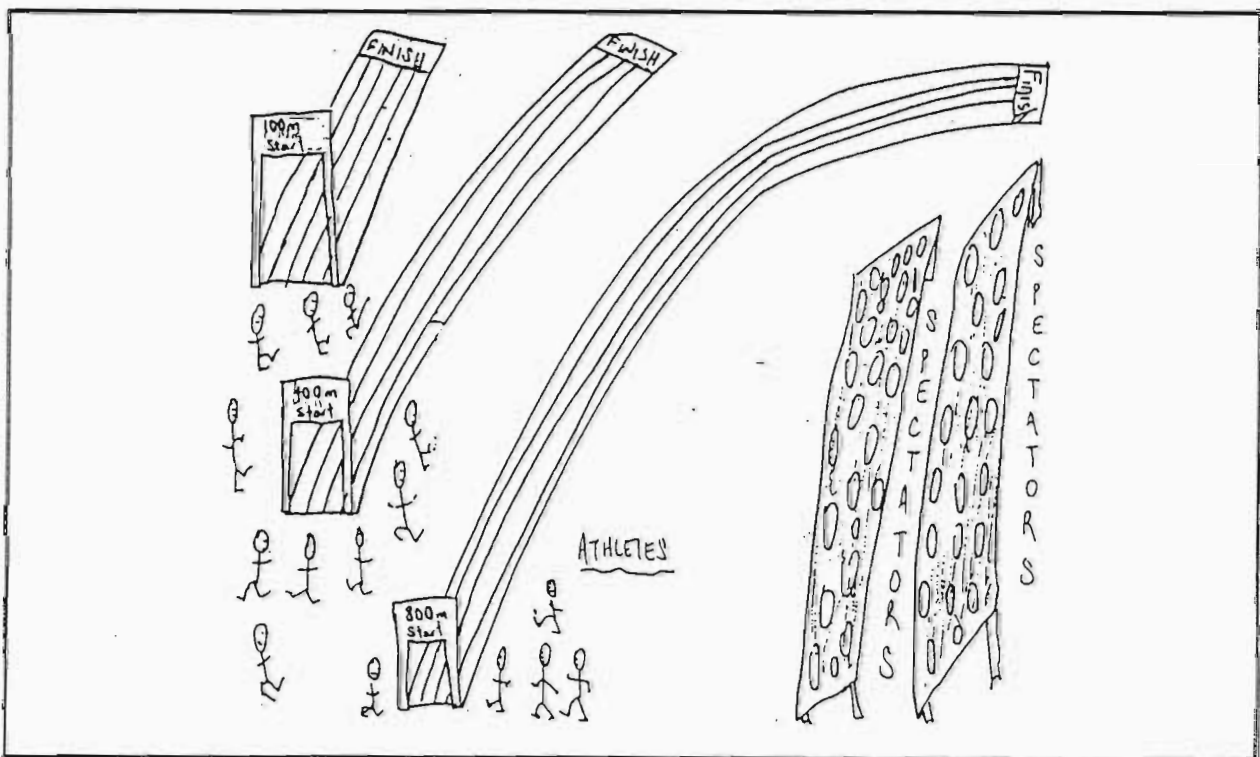
*The teacher must be able to teach each and every child in the classroom, The teacher must be able to let them work in groups effectively.*

The situation described here seemed less than ideal and indeed Siphso explained in the interview that this was more how he saw the current situation than his vision for how things ought to be. He envisaged more attention being paid to the less mathematically able pupils in the class.

*These are the good ones. You can give these the guidelines how to do it. Then you are supposed to concentrate more on those who are battling. (Siphso 2SC)*

In this metaphor, the teacher instructs the learners in the procedures to be followed and ensures that they practise. Fox (1983) remarks that “these teachers (shaping theorists) frequently use the language of the athletics coach” (p.153).

### *Travelling Theory*



**Figure 7** Myron's Vision of the Way Things Ought to Be.

#### Explanation

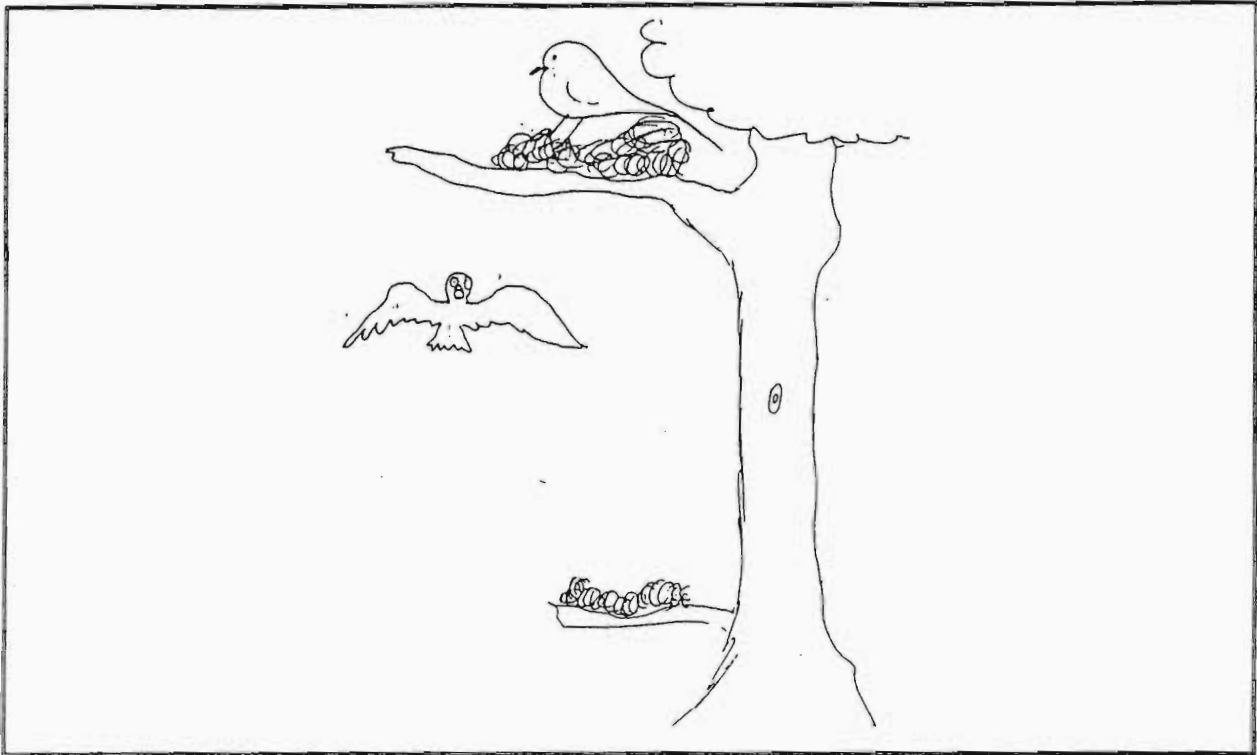
*Each race symbolises each learner's ability to learn. (Some are shorter and would take less time while some learners are rather slow).*

*The spectators are the facilitators encouraging the athletes (students) to improve on their performance or to keep it up.*

*The athletes are the students striving to complete their race (task) and gain knowledge at the end of the race.*

The supportive role of the teacher and the independence of the learners to achieve their personal goals were indicative of this being a travelling theory.

### *Growing Theory*



**Figure 8** Marc's Vision of the Way Things Ought to Be.

Explanation.

*The teacher is the big bird.*

*Flight is the lesson.*

*The small bird is the learner.*

*This is good for high school pupils only as strength has been achieved by prior coddling. The short drop, learning to fly, will help the younger bird to one day soar to great heights.*

This was classified under the Growing Theory on the strength of the emphasis of the personal development of the learner. During the interview, Marc added to his written explanation of his metaphor.

*I think to be the big bird in this type of teaching you have to be very sensitive and you have to do things in such a way that you can assure the little bird that you are not trying to kill it and you are not sending it out on a mission where the little bird is just going to flop. The big bird has to be very sensitive and has to do things in such a way. For me Prac teaching is not about doing well, it is about learning well. I am going to try and learn the ways best that I can be like that big bird. I mean to try and develop means and ways that I can teach in this way.*

### 4.2.3 General observations about the personal theories of preservice Mathematics teachers

The metaphors drawn by the preservice teachers were predominantly typical of simple theories of teaching and learning. Of all the metaphors that could be classified, 94% were indicative of simple theories and in the Third year group all the metaphors indicated simple theories.

Confirming evidence of this strong leaning towards simple theories of teaching came from the interviews with preservice teachers. In the course of the interviews, students were asked if they felt they had changed their ideas at all since coming to college. In response to this question, several of the students had high praise for a College lecturer of Mathematics who had taught them the previous year. This lecturer seemed to me to typify the “old school” - his knowledge of the subject content was excellent, but his lectures seemed to be a predictable cycle of explain, practice, review. This appeared to the preservice teachers to constitute exemplary teaching.

*The way I saw Mr Pike last year, he taught the lesson, I also saw in that lesson that he understands the lesson. He gave us all the information we need. (Sipho 2SC)*

*Mr Pike told us everything in the class... ..It was the right way to teach. (Mangiso 2SC)*

*I think with his approach, its more a case of this is how it is done, this is an alternative approach to doing it. Go home and do it yourself and then the next day we are starting something new. Mr Pike showed you extension work in the classroom but he never used to test you on it, he always used to test you on classwork that you had done and if you have done the exercises you will be able to fly through the test... ..I think I will teach the way I have been lectured. (Penny 4SC)*

It appears that the preservice teachers participating in this study favour a transmission mode of teaching both when they are the teachers and when they are the learners. It could be that they have had experience of little else.

If the data from the responses to the teaching dilemmas of Activity Two are included with the data from the metaphors, a more complete picture emerges. The quantitative analysis of the responses is tabulated in Table 11, Table 12 and Table 13 below.

**Table 11 Classification of the Personal Theories of Second Year Students**

SECOND YEAR STUDENTS	ACQUISITION METAPHORS			PARTICIPATION METAPHORS	
	SIMPLE THEORIES			DEVELOPED THEORIES	
Theory-in-use	Transfer	Shaping	Travelling →Transfer	Travelling	Growing
Jane's Story	6		5	3	
Richie's Story	8	1		4	1
Ms Jones' Story	6			3	
Metaphor 1	6	2		2	
Overall	26	3	5	12	1

**Table 12: Classification of the Personal Theories of Third Year Students**

THIRD YEAR STUDENTS	ACQUISITION METAPHORS			PARTICIPATION METAPHORS	
	SIMPLE THEORIES			DEVELOPED THEORIES	
Theory-in-use	Transfer	Shaping	Travelling →Transfer	Travelling	Growing
Jane's Story	13	0	2	1	0
Richie's Story	7	4	2	2	1
Ms Jones' Story	2	0	7	4	0
Metaphor 1	8	4	0	0	0
Overall	30	8	11	7	1

**Table 13: Classification of the Personal Theories of Fourth Year Students**

FOURTH YEAR STUDENTS	ACQUISITION METAPHORS			PARTICIPATION METAPHORS	
	SIMPLE THEORIES			DEVELOPED THEORIES	
Theory-in-use	Transfer	Shaping	Travelling →Transfer	Travelling	Growing
Jane's Story	5	1	6	6	0
Richie's Story	11	1	1	4	2
Ms Jones' Story	1	0	2	4	0
Metaphor 1	9	2	0	0	1
Overall	26	4	9	14	3

If the travelling-to- transfer theory is considered a simple theory, the overall support for simple theories of teaching comes to 76%. There are quite marked differences between the year

groups: the Second year students show a 72% support for simple theories, the Third Year students a 86% support and the Fourth Year students only a 70% support.

### 4.3 IMPLICIT THEORIES HAVE CONSEQUENCES

It is appropriate to reproduce a quotation used earlier, since it provides the heading to this section:

Teachers' implicit theories are more than private matters of personal taste and opinion. They can have dramatic consequences... Implicit theories can make a difference. **Implicit theories have consequences.**" (Clark, 1992, pp.78-79)

This section deals with the third research question:

**Are preservice teachers aware of the links between their personal theories and their classroom practice?**

Assertion Three

**Preservice Mathematics teachers regard personal or formal theories of teaching and learning Mathematics and classroom practice as separate areas of study.**

The learning activities constructed to generate data to inform this question were designed to raise awareness of the links between personal theories and classroom practice as much as to test for the presence for such awareness.

#### 4.3.1 Reading Activity - Personal Conceptions of Teaching and Learning

The first activity was a reading activity described previously on page 49 and in Appendix E. As a first step in raising awareness of their personal theories being linked to their own personal practice, general indicators of each of Fox's four teaching conceptions were sought (Fox 1983). This was a routine activity, heavily based on the text. More useful empirical material was generated by the last question:

"Do you think it is possible that a teacher could hold different beliefs and operate according to different theories depending on the occasion?"

*The individual maintains their theory however may vary their strategies in teaching within their theory. to allow for differences in subject matter they are teaching.  
(Claire 3SC)*

*It is possible to alter your strategy depending on the occasion. Time constraints may*

*also play a role in determining your strategy. However, I don't think it's possible to hold different principles. You would be compromising your basic principle. (Seema 4SC)*

These preservice teachers seemed to appreciate the connection between theory and practice and saw personal theories as guiding principles. On the other hand, many of the preservice teachers confused personal theories with teaching strategies and consequently thought they could be adopted and discarded at will. Typical responses to the question included:

*Yes, definitely. It depends on what you are teaching and the content, as well as how you feel on that day. (Kirsten 4 SC)*

*It depends on the group that the teacher teaches. It's useless to use transfer theory in the class of brilliant or clever students. (Siyabonga 3 SC)*

#### **4.3.2 Teaching Activity - Practical Teaching based on Particular Conceptions of Teaching and Learning**

Following the reading activity was a teaching activity in which preservice teachers were required to prepare and teach a particular school Mathematics topic as they thought a particular theorist might do (see page 49 and Appendix F). This activity had a double purpose in that the other students in the group would try to discern the particular theory-in-use being portrayed. The desired outcome was a heightened awareness of the close relationship between personal theories and classroom practice. However the response to this activity was most disappointing. There was a general reluctance on the part of the preservice teachers to engage with the task and to do the necessary research to produce novel and suitable lessons for their particular topic and theory. This could be attributed in part to the timing of the activity which was in the weeks leading up to the first Semester examinations. Students were concerned about these, and in addition there was a week of student protest because no study leave was granted. All of this, (and the subsequent granting of study leave) resulted in long intervals between the lecture periods for Mathematics Education and the whole activity lost momentum. When preservice teachers presented their lessons, it was seldom apparent to either me or the rest of the class which theory was in use. Indeed even the presenting group could not always make a convincing case for their theory-in-use.

*Very disappointing really. No spark or creativity in lessons. Two students are simply copying work from a previous activity. (Researcher's fieldnotes 5 May 1998)*

It was possible to observe some of the preservice teachers during their Teaching Practice period. Because of the fleeting nature of the school visits and the many constraints on the

student teachers in the schools, I do not believe that much can be inferred from this observation. In most cases I was only able to observe three lessons for each person. I had hoped to have sufficient freedom during this period to follow a few focus students more closely but the staffing position at the College where I am employed did not allow for this. Although the preservice teachers were asked to keep their metaphors in mind, even to the point of pasting them into their lesson preparation books, there was little evidence that this was done.

The answer to the research question that begins this section remains largely unanswered by direct empirical evidence. The assertion that the preservice teachers regard educational theories (their own or otherwise) and classroom practice as two entirely distinct areas of study must consequently be regarded as tentative.

#### **4.4 CHANGING A PERSONAL THEORY**

The focus of this section is on the fourth research question:

**Do preservice teachers view their personal theories as developing or complete?**

##### **Assertion Four**

Preservice teachers who are disposed towards reflecting on their practice are willing to change their personal theories of teaching and learning Mathematics to accommodate new experiences.

##### **4.4.1 General remarks**

The final activity in this study informed this question. In order to get an overall idea of the preservice teachers' openness to change, a count was done as to how many participants expressed a change in their metaphors for the teaching and learning of Mathematics. Of course, there is the possibility that a participant who is open to change carefully reconsidered his/her initial metaphor and decided to retain it. I would be surprised if this was the case, but nevertheless it would be prudent to allow for this possibility.

**Table 14: Number of Preservice Teachers who amended their initial metaphors for the teaching and learning of Mathematics.**

Year of Study	Metaphor Unchanged	Metaphor Changed	No initial metaphor	TOTAL
SECOND	6 (43%)	7 (50%)	1 (7%)	14
THIRD	5 (29%)	10 (59%)	2 (12%)	17
FOURTH	12 (63%)	5 (26%)	2 (11%)	19
TOTAL	23	22	5	50

There are very marked differences between the year groups. In the Third Year group, twice as many students changed their metaphors as elected to allow their initial ideas to stand. This proportion was reversed for the Fourth Year group.


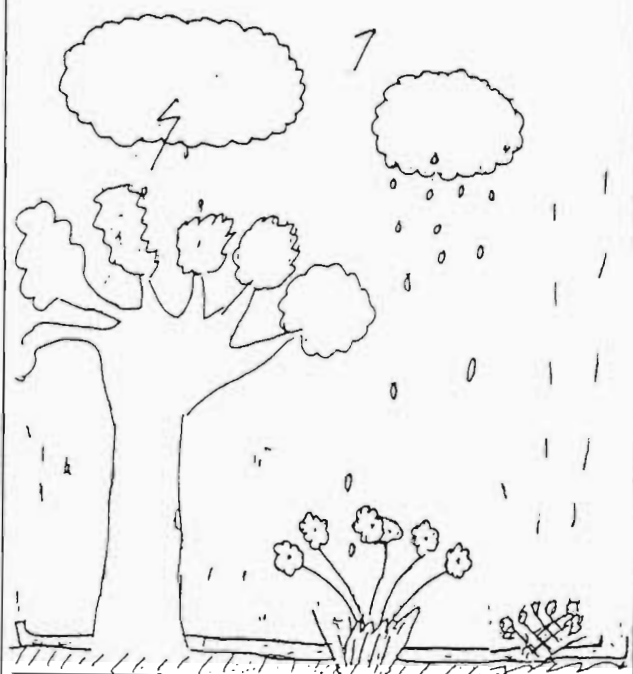
#### **4.4.2 Nature of learners as an impetus to change**

The nature of the class that was taught seemed to have a strong influence on changes in preservice teacher thinking – a phenomenon that has been noted by other researchers in the field.

Young people are a powerful force in the classroom, and the most significant source of change in thinking about self as teacher....Just as teachers seek to influence pupil behaviour, pupils influence and shape a teacher's behaviour as roles and relationships are negotiated (Bullough & Gitlin, 1995, p.62).

Some students felt the need to concentrate more on weaker pupils and modified their metaphors accordingly. This is evident in Sameer's metaphors that are reproduced below.



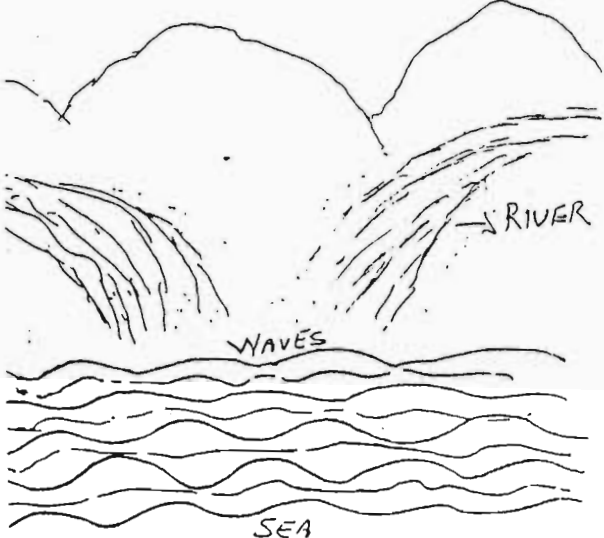
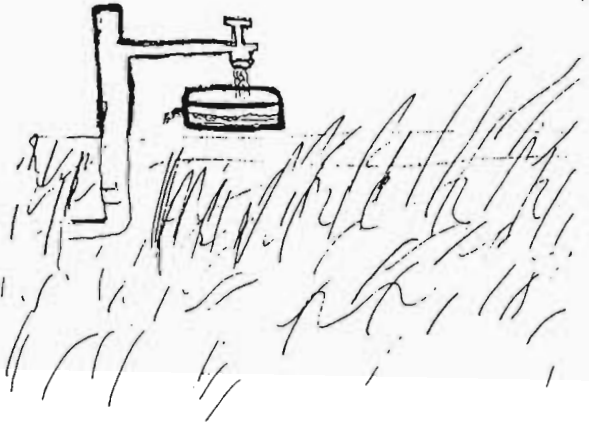
Original Metaphor for the teaching and learning of Mathematics	Reconsidered Metaphor for the teaching and learning of Mathematics
	
<p><i>Here the teacher would be the clouds. The rain would be the knowledge. The pupils here are the plants and leaves, obtaining the rain, which in fact is the knowledge.</i></p>	<p><i>Here again the teacher would be the clouds. The rain would still be the knowledge. The pupils are the plants, leaves, and the grass who are obtaining knowledge, which is the rain. A drain is now provided which collects the knowledge and carries it to the weaker pupils who in fact are receiving individual attention.</i></p>

**Figure 9: Sameer's Original and Reconsidered Metaphors for the teaching and learning of Mathematics**

Other students seemed disillusioned at the poor ability of the learners, their lack of motivation and culture of learning and tried to modify their metaphors to accommodate this. The senior students seem to have accepted the reality of a range of abilities in the classroom but viewed this as a constraint on their practice.

This is well illustrated by the metaphors suggested by Vusi. (3SC). Vusi's initial metaphor was not classified as it did not seem coherent. He explains his change in personal theory as follows:

*Like I went into Practice teaching with travelling theory. Due to different intellectual abilities of learners I had to change my theory and accommodate everyone in the classroom. The misbehaviour of learners during lessons cause you to go for a theory that will give less opportunity of misbehaving.*

Original Metaphor for the teaching and learning of Mathematics	Reconsidered Metaphor for the teaching and learning of Mathematics
 <p><i>WAVES: facilitator</i>  <i>RIVER: learner</i>  <i>SEA: classroom</i></p> <p><i>Rivers play the role of learners coming to the maths class. Because Maths is difficult, waves serve as a teacher who screens water so that they will become part of the class.</i>  <u>Maths knowledge:-</u> <i>The process of refining water so that all unwanted material is removed.</i></p>	 <p><i>TAP: the facilitator</i>  <i>BUCKET: the learners filled with knowledge</i>  <i>KNOWLEDGE: Water</i></p> <p><i>Here we have the teacher who is giving knowledge to learners. i.e. tap providing water that goes into the bucket.</i>  <i>The bucket serves as a classroom with slow learners and quicker learners, because the teacher is bearing his theory and other theories. Only few learners find the classroom not a good place for them. As you can see the bucket is leaking at the top.</i></p>

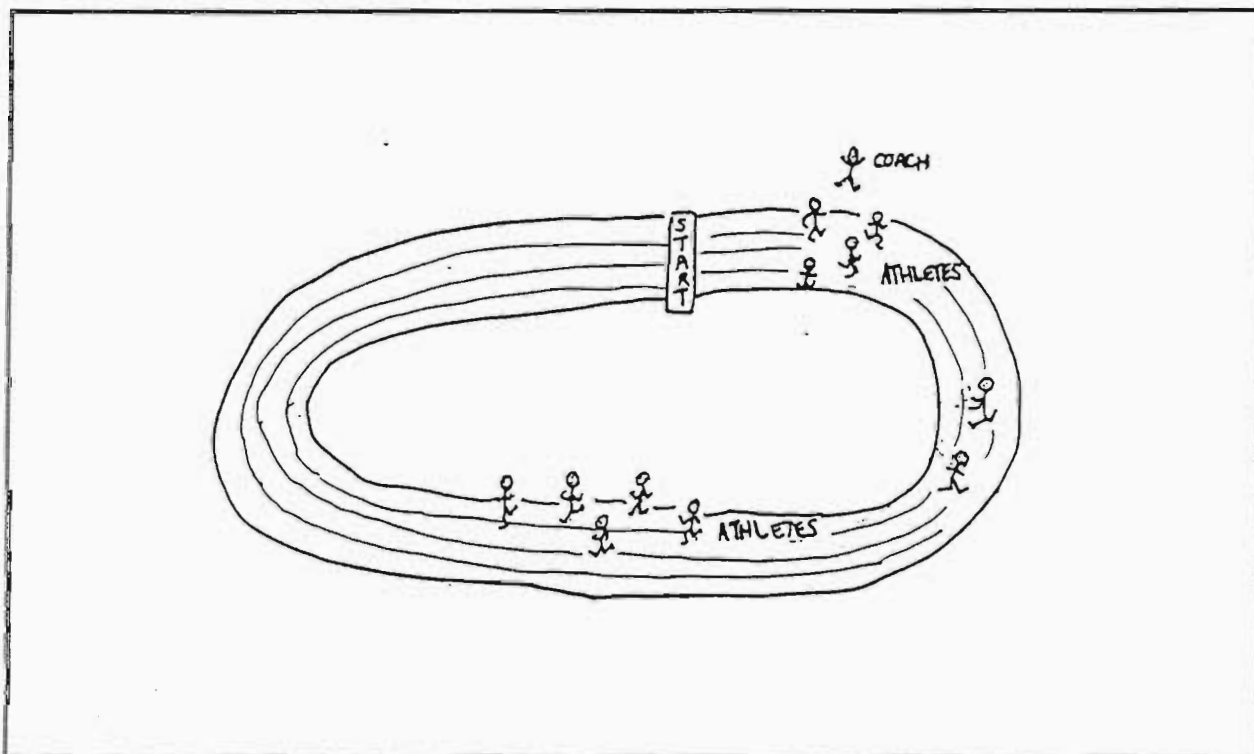
**Figure 10: Vusi's Original and Reconsidered Metaphors for the teaching and learning of Mathematics**

#### 4.4.3 Examples of Changes in Metaphors

The experiences of the year did not have the same effect on all students. Despite the hope of the College staff that preservice teachers would move towards more developed theories of teaching and become more progressive in their thinking this was not always so. The following three examples show the range from a retrogressive change, through no change at all, to a move towards a more developed theory.

##### *From a Developed Theory to a Simple Theory*

Myron's initial metaphor showed athletes all running their own race with the teachers in a supportive role (see Figure 7 on page 72 ) His was one of the very few developed theories identified. His reconsidered metaphor is shown below.



**Figure 11: Myron's Vision of the Way Things Could Be - Reconsidered Version**

##### Explanation

*The learners are now all running the same race.*

*The facilitator is now the coach who is assisting the slower ones and not worrying too much about the learners that are ahead.*

This seems to be indicative of a shaping theory-in-use. In the questions that accompanied the task to reconsider the metaphors, Myron wrote:

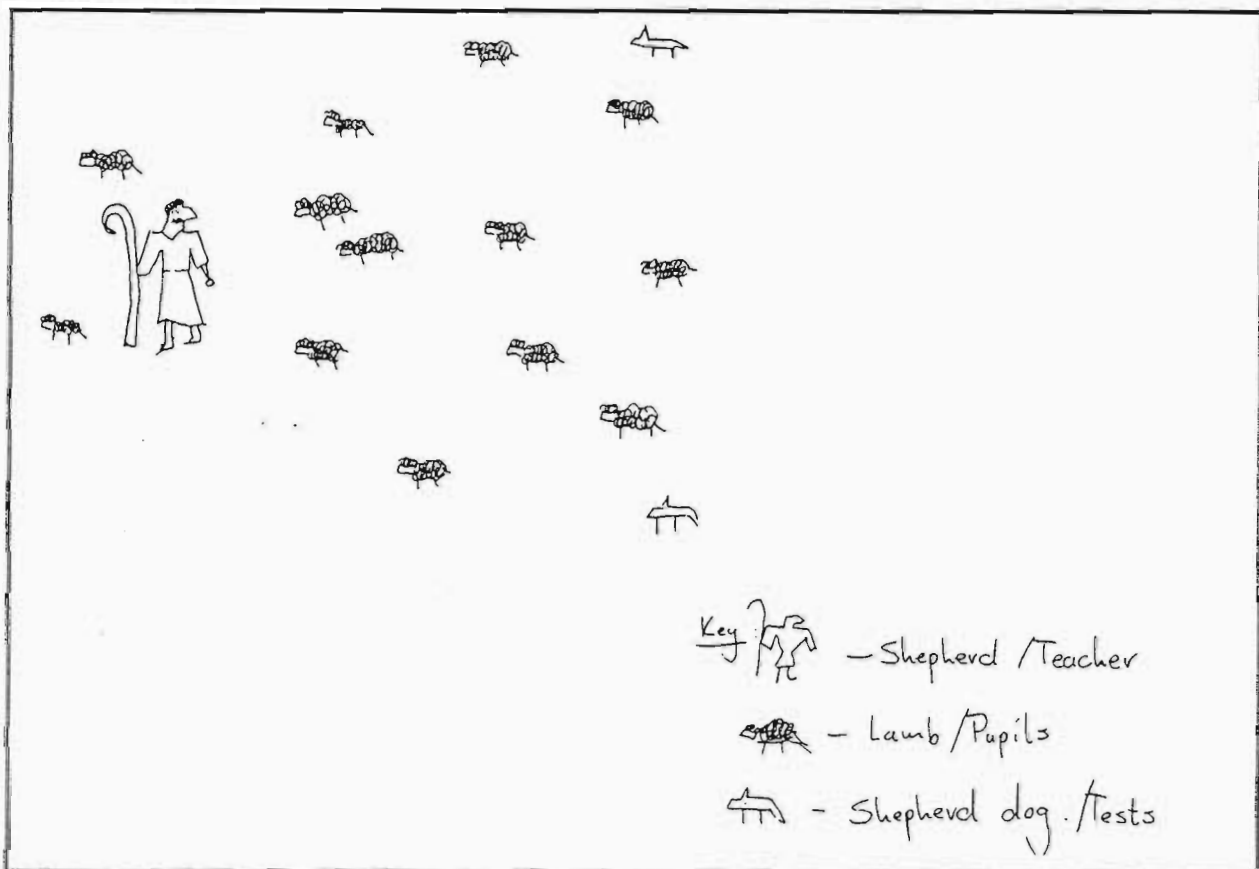
*It (Teaching Practice) definitely challenged my metaphor. In my metaphor, I stated that all learners learn at their own pace and should therefore be taught differently. There were some learners however that did not want to learn at all. ... I taught all the learners at the same pace but during the groupwork I assisted the weaker learners more regularly and gave them more attention.*

### *From a Developed Theory to a less Developed Theory*

Marc (4SC) was the only preservice teacher to suggest a metaphor indicative of a Growing Theory and it is interesting to see how his metaphor stood up to the demands of Practice teaching. He set off with the intention of being a “big bird” that would nurture the “little birds” for a while and then allow them to fly out of the nest and “fall or fly”. (see Figure 8 on page 73). After Teaching Practice, he wrote:

*I felt that I cared too much to let the pupils fall and fail. My approach was to let the others learn for themselves and pay special attention to those who failed.*

Marc then drew and described an alternative metaphor:



**Figure 12: Marc's Vision of the Way things Could Be - Reconsidered Version**

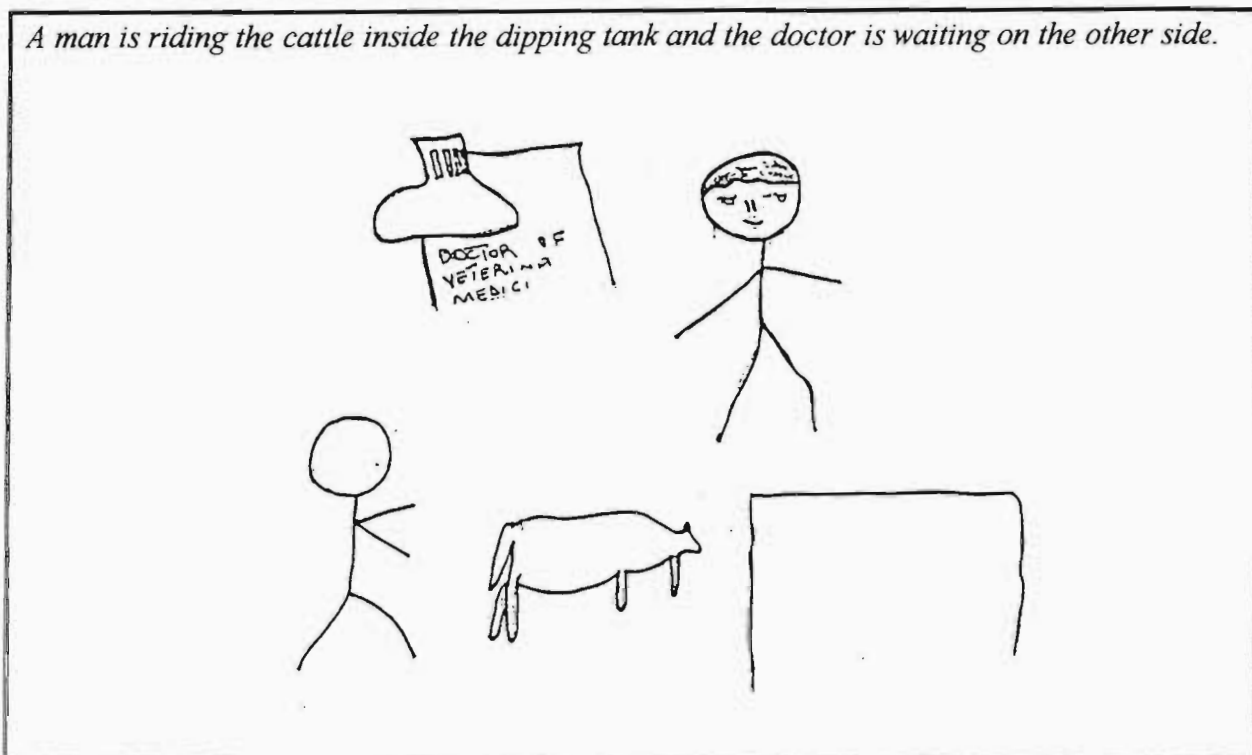
#### Explanation

*The teacher leads and guides in a direction (work), offering challenge, respect and direction. The pupils may choose to follow or go wayward. Tests or assignments (dogs) would help them to see for themselves where they are getting lost.*

This is still a developed theory but seems to be more typical of a Travelling theory.

### *Retaining a Simple Theory*

The original metaphor suggested by Sandile expressed a teacher-dominated and authoritarian personal theory of teaching and learning. This is reproduced below.



**Figure 13: Sandile's Vision of the Way Things Ought to Be**

#### Explanation

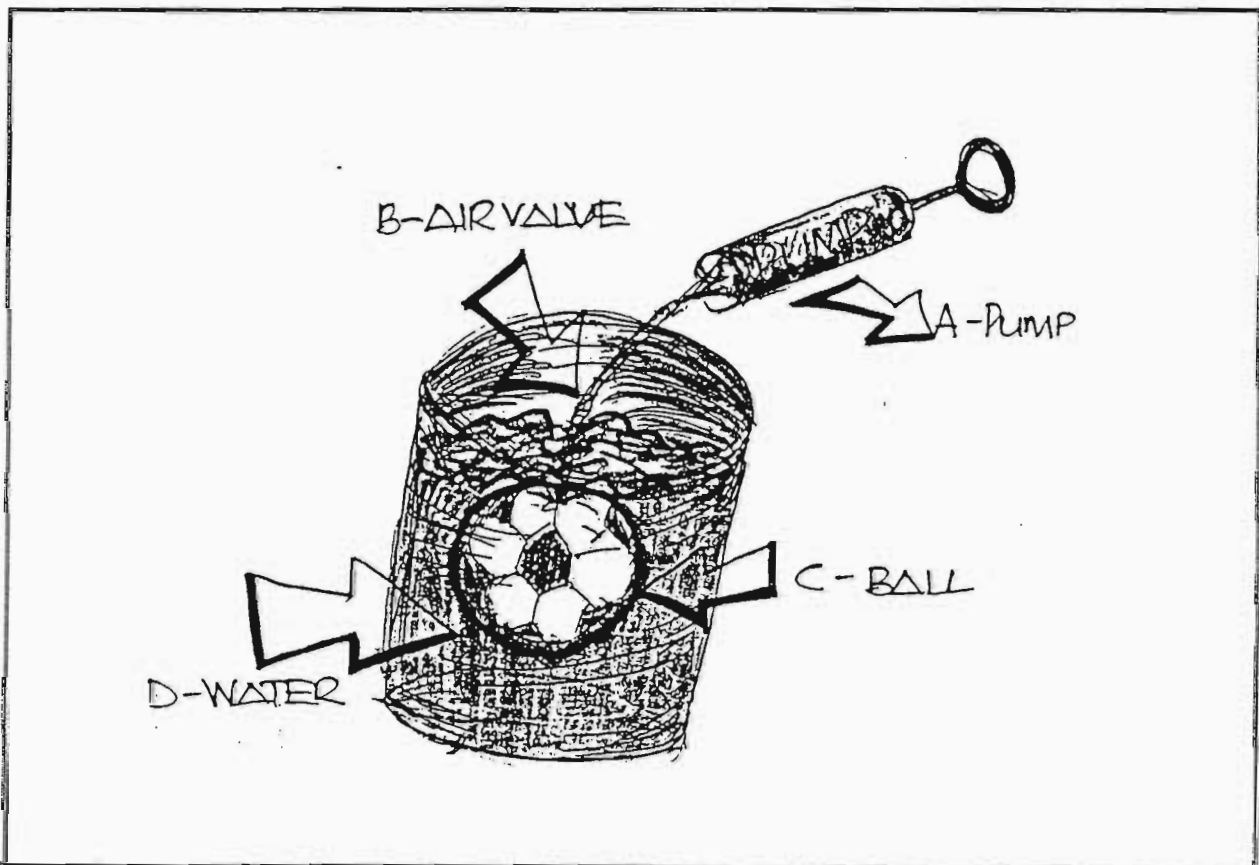
*Teacher in this case is the doctor. Learners are the cattle. Mathematical knowledge is the water inside the dipping tank. As seen in the picture, maths occurs as animals go inside the dipping tank. The doctor inspects the animal and it proceeds to the water. The learners come to school ignorant and willing to enquire (knowledge). As he/she comes he is being enlightened by the teacher and prepared to become a better citizen. So he/she accepts what is being taught by the teacher and wants to apply it on his/her own.*

When asked to reconsider his metaphor, Sandile chose to retain his original drawing and offered the following explanation.

*I have always believed that pupils must be guided in everything they do because in the lower grades i.e. 9 and 10, pupils are not in the position to discover things on their own except those who are highly intelligent. So I haven't changed my personal theory. The teacher is the one who is supposed to lead pupils to new terrain. Because if learners are left on their own, they can easily go astray.*

*From a Simple Theory to a more progressive Simple Theory*

Steve (3SC) initially suggested a metaphor of a pump filling a ball with air to describe how he saw the teaching and learning of Mathematics (see Figure 5 on page 70). During the interview, he readily conceded that this metaphor had weaknesses, chiefly that the teacher was portrayed as the sole source of knowledge. When given an opportunity to reconsider his metaphor, he amended it to include the possibility of the learner gaining knowledge from a variety of sources. This is still suggestive of a Simple Theory since the knowledge is being transferred, but the provision for different sources of knowledge indicates progress towards a more developed theory.



**Figure 14: Steves's Vision of the Way Things Ought to Be - Reconsidered Version**

**Explanation**

*Pump can be regarded as the teacher. Attached from the teacher to the learner (ball) is a valve which can serve as a passage for the Mathematics knowledge. However this is not the only source of information. The water serves as the external passage which the learner can use to obtain mathematical knowledge. Osmosis through the water can occur and the ball will be filled. So the teacher is not the only source of mathematical knowledge.*

#### 4.5 SUMMARY OF RESULTS

The notion of considering personal theories of teaching and learning Mathematics was new to the preservice teachers participating in this study. Although they did not initially suggest personal theories as a component of their Mathematics Education course, the preservice teachers interviewed indicated that they had found it helpful to reflect on their own beliefs. The responses to the critical incidents and the metaphors created for the Mathematics teaching/learning experience indicated that the vast majority of preservice teachers participating in this study hold simple, acquisition type theories of teaching and learning. Despite deliberate efforts to raise awareness of the probable link between their personal theories and their classroom practice, the connection was not clearly evident to the preservice teachers. Consequently, they did not seem to realise the consequences of their personal theories. When given the opportunity to amend their initial metaphors for the teaching and learning of Mathematics towards the end of the year, only about half of the participants in the study altered their metaphors in some way. The remaining preservice teachers either considered their personal theories complete, or they lacked the disposition to consider changing their theories.

These results and their implications for a professional Mathematics Education course are discussed further in Chapter Five.

## CHAPTER 5

### DISCUSSION

This study spanned an academic year in the preservice teaching training course. For some participants it was their second year of study, others the third, and for some it marked their final year of study. It could be expected then, that these people would bring to this course different levels of knowledge, skills and values. The Mathematics Education programme described was a first attempt to go beyond “tips for teachers” in this initial stage of the preservice teachers’ professional development. Some of the results of this programme were as I had anticipated, some were surprising, but all were interesting and important to the future development of this course.

The following discussion of the results of this study is centered in turn on each of the research questions and the consequent assertions.

#### **5.1 WHAT IS THE PERCEIVED ROLE OF PERSONAL THEORIES IN THE PROFESSIONAL DEVELOPMENT OF PRESERVICE MATHEMATICS TEACHERS?**

##### **Assertion One**

Preservice Mathematics teachers do not intuitively perceive consideration of personal theories of teaching and learning Mathematics as an important component of a Mathematics Education course.

If the metaphor of good Mathematics teaching as a four legged table, with Mathematics Content Knowledge, Pedagogical Content Knowledge, Pedagogical Reasoning and Personal Beliefs forming the four legs, is applied to the preservice teachers participating in this study, the tables will indeed be very wobbly. The problem with wobbly tables is that they look fine and they perform well with light loads but it is when it matters most, when the load is heavy and conditions are changing, that the defect becomes obvious and troublesome.

The participants in the study were asked to identify five desirable outcomes of a Mathematics Education course. These were then classified according to the four legs of the table mentioned



above. The College curriculum separates the students' personal study of each subject specialisation from the study of how to teach that subject. This means that the Mathematics Content Knowledge "leg" is seen as separate from the Mathematics Education course. It would not thus be expected that preservice teachers would identify such knowledge as being an important outcome of the Mathematics Education course since it is the focus of the academic Mathematics course.

From the responses to the initial activity of this study, it was clear that the preservice teachers saw the most important component of the Mathematics Education Course to be general teaching skills, followed by Pedagogical Content Knowledge, with beliefs, attitudes and theories coming in a poor third. The last place of Mathematical Content Knowledge was expected for the reasons set out above, and does not provide an authentic measure of the importance participants attach to this component. I have no doubt that the students attach considerable importance to the academic Mathematics component as it is generally taken for granted that a teacher should know his/her subject.

Despite an initial lack of interest and/or awareness of beliefs and theories as a fruitful area of study, many of the students did appear to enjoy thinking about their beliefs, at least on a superficial level. Over the year, I came to realise that the students were very concerned about their survival in the classroom, and indeed many of them undertook their teaching practice in rather undisciplined conditions. It is not difficult to understand that such preservice teachers are not inclined to devote their energies to examining their personal beliefs and philosophies of education. Nevertheless, preservice teachers should begin the process of personal theorising at the outset of their professional training and regard this as a career long process. Apart from the intrinsic value of professional self development, being a lifelong learner is a stated role for educators in the new Norms and Standards for Educators document (see page 4).

The title of Hill's article: "Just Tell Us The Rule - Learning to Teach Elementary Mathematics" (1997) indicates a similar dismissal of discussions of concepts and theories in favour of working methods and an instrumental understanding. There is an obvious problem when the curriculum valued by the course lecturers and the curriculum perceived by the students as being useful and appropriate differs. This raises the issue of negotiating a curriculum. The onus is on both parties to provide a convincing argument for the inclusion of aspects of the

curriculum. The students need to be convinced of the fruitfulness of pursuing a line of inquiry. In this context, the preservice teachers need to appreciate the benefits to their professional development of reflective personal theorising.

I think the activities of the course were worthwhile since, at the very least, after participating in the activities of the Mathematics Education course, preservice teachers should have developed an idea that their own theories are in fact personal beliefs, distinguishable from knowledge in that they are clearly disputable. I think that this acknowledgment that one's ideas about teaching and learning do not necessarily reflect a universal truth is an important step on the way to change.

## **5.2 WHAT PERSONAL BELIEFS ABOUT THE TEACHING AND LEARNING OF MATHEMATICS DO PRESERVICE MATHEMATICS TEACHERS HOLD?**

### **Assertion Two**

The personal theories of teaching and learning Mathematics held by preservice Mathematics teachers are typically of an acquisition or simple nature.

In essence, the preservice teachers participating in this study subscribe to simple theories of teaching and learning. If the drawn and described metaphors for the teaching and learning of Mathematics are taken as indicators, 94% of the participants favour acquisition type metaphors which correspond to simple theories of teaching. When the responses to critical teaching incidents are included, the percentage favouring simple theories drops to 75%. Some of the other apparent core beliefs are discussed below.

### **5.2.1 “Teaching by telling.”**

What is the significance of the overwhelming support for transmission type teaching? Simple theories of teaching, which correspond to acquisition type metaphors, lead to a “teacher tell” style of teaching which is particularly unsuited to Mathematics where the emphasis should be on personal sense making.

Davis (1992) concluded the Handbook of Research on Teaching and Learning Mathematics with some thoughts on the way forward for Mathematics Education. He identified fifteen challenges and opportunities facing research and development in this field. The sixth of these

related to the study of the effect of assuming that teachers must “tell” students how to do Mathematics. This assumption was certainly strongly held by many of the participants in this study as indicated by the vast majority who held simple personal theories of teaching and learning. These preservice teachers would probably agree that unless pupils are told how to solve Mathematics problems, many pupils will become lost and will quickly become demoralised. On the other hand, those who challenge this assumption assert that this “telling” sends a message to the pupils that they are incapable of mastering the subject without this input. Soon they give up the habit of thinking for themselves and adopt the strategy of trying to remember what the teacher said (Davis, 1992). Opponents of “telling” feel that this attitude renders pupils almost incapable of making progress in Mathematics. More alarming is the assertion that this learned helplessness is not inevitable, but is the result of implicit messages repeatedly sent by teachers. It is my conjecture that Shaping Theorists in particular send such messages. It is ironic that teachers trying to be helpful by insisting on attention as they demonstrate carefully step by step (watch carefully otherwise you will get lost!) could in fact be disempowering the learners.

Why then, despite the evident futility in many cases, do teachers insist on “telling”? In the case of Richie’s Story, many preservice teachers suggested that since Richie had not understood the first time they should “explain again”. This is neither a novel nor recent viewpoint as evidenced by the following observation by Kline (quoted in Ball, 1988):

Mathematicians have a naïve idea of pedagogy. They believe that if they state a series of concepts, theorems, and proofs correctly and clearly, with plenty of symbols, they must necessarily be understood. This is like an American speaking English loudly to a Russian who does not know English. (p. 117)

The analogy of speaking a foreign language is close to the truth in many South African classrooms. Adherence to a theory that supports a transmission mode of teaching is problematic in classrooms that are multicultural and multilingual, since the dominant mode of delivery is through the medium of language. When a learner is being schooled in his/her second language, this emphasis on the spoken word of the teacher as the prime source of knowledge could be a barrier to learning.

In the past, textbooks written for aspirant teachers of high school Mathematics have communicated the idea of the teacher being the sole source of knowledge. In discussing an exemplary lesson in such a textbook, Kroeze (1989) indicates that “during the second or

presentation stage the actual new knowledge must be transferred from the teacher to the pupils”(p.37). I am not sure that this “telling” teaching strategy favoured by the preservice teachers stems from a deep conviction that it is a successful strategy, as much as from a lack of alternatives with perceived viability. This suggests a direction for professional Teacher Education courses.

### 5.2.2 Practice makes Perfect

Arising from the well known teaching cycle of explain, demonstrate, practice, is a belief that the learners’ role in the teaching/learning process is to listen, watch and practise. Failure to learn the Mathematics is often ascribed to lack of practice and many preservice teachers firmly believe that practice makes perfect. I consider this a simplistic view and rather contend that meaningful practice assists in sense making. In the course of an interview, Mangiso (2SC) describes how this idea of practising is important.

*When I am doing Maths - you need to practise everyday. Like when you have done the task today, then go and practise at home. Tomorrow you will know what was happening yesterday.*

The last sentence epitomises hope. Perhaps what this student is hinting at is that personal sense making is the vital ingredient in understanding. I agree with this to the extent that practice certainly aids in skills development, but I am not convinced that practice develops understanding.

### 5.2.3 Validity of the empirical material

The participants in this study were preservice teachers who had only limited experience of teaching. It would not have been realistic to expect that they would have clearly thought out personal theories, which they could describe in a consistent, coherent and articulate manner. This study however sought to catch glimpses of the implicit theories of the participants. The following aspects of the study were potentially problematic in generating authentic empirical material.

#### *Leading nature of the tasks*

The dominance of the transfer theory in the metaphors could be the result of the way in which the task was phrased. This was pointed out by colleagues who suggested that asking preservice teachers to identify the teacher, the learners and the mathematical knowledge in some way

suggested that the knowledge was a commodity that could be drawn, and the teacher was essential to the learning process. This could well be the case and gave me cause for concern. In the discussion prior to drawing the metaphors I had provided an alternative explanation of a given example of a metaphor in which the teacher was not visible. It is hoped that the group discussion of metaphors was sufficient to indicate the open nature of the task.

#### *Order of data collection*

The order in which the empirical material was collected was important. In order to access the basic starting beliefs of the participants it was essential to get their thoughts down in writing before they were presented with any formal theories. This was borne out by the metaphors produced by two students who had been absent at the proper time. In order for their course work to be complete, they submitted metaphors after the reading by Fox (1983) and class discussions had taken place. Both these students produced metaphors typical of developed theories and reminiscent of some metaphors described by Fox (1983). These were not included in the data set because I could not be sure they represented the participants' initial personal theories.

A major limitation of interpretive research of this nature is the small sample size which impacts on the generalisability of the data (Gallagher, 1991a). It is not certain that the trends observed can be generalised beyond the particular College context in which this research is situated.

### **5.3 ARE PRESERVICE TEACHERS AWARE OF THE LINKS BETWEEN THEIR PERSONAL THEORIES AND THEIR CLASSROOM PRACTICE?**

#### **Assertion Three**

Preservice Mathematics teachers regard personal or formal theories of teaching and learning Mathematics and classroom practice as separate areas of study.

#### **5.3.1 Theorising Practice or Practising Theory**

It seems evident to me that people interpret the world around them according to their particular life view, and that this in part explains the conflicting ways in which different individuals perceive reality. There is no reason why this should be different in the educational sphere.

However this strong link between personal life view and perceptions, and consequently actions did not appear to be evident to the preservice teachers participating in this study. Despite several attempts to highlight this point, I doubt the connection was made. It seemed to be very difficult for the preservice teachers to discern the difference between a personal belief that underlies practice and a particular teaching strategy.

The motivation for highlighting the link between implicit theories and practice was to provide an impetus for reflection and a prompt for change. An awareness of a discrepancy (or an appreciation of a match) between an espoused theory and a theory-in-use could be a first step in professional development.

Teachers (preservice and in-service) should have a rationale for each of the learning experiences they plan. They should know why they regard an activity as good and worthwhile, and why they have disregarded other alternatives. It ought to be clear to the teacher how learning will be promoted through the activity, and evidence should be sought for this learning. In a sense, they should theorise their practice, always bearing in mind that consciously or unconsciously they are practising their theory. A good starting point for such reflective practice is the Teaching Practice component of the preservice Teacher Education programme. In addition, teachers need a repertoire of learning activities suitable for more developed theories of teaching and learning. A lack of such resources could lead to a teacher with a fairly developed personal theory of teaching adopting a simple theory-in-use.

### **5.3.2 Teaching Mathematics above teaching children**

A consideration of the inferred personal theories of the preservice teachers shows some striking patterns. If we follow Fox (1983) and attempt to classify the conceptions of teaching into Transfer, Shaping, Travelling and Growing Theories, it becomes clear the vast majority of participants in this study with simple theories of teaching favoured the Transfer theory, and the Travelling theory was the more popular of the developed theories. What I found striking was that these were the two theories that Fox (1983) identified as being linked to teaching a subject rather than teaching people. In other words the verb “teach” refers to Mathematics rather than learners. How would this fit in with the Curriculum 2005 initiative? I would suggest that the informal personal theories inferred from this study and the formal theories underpinning

Outcomes Based Education show little, if any, overlap. How can we reconcile a strong leaning towards teaching the subject content with an emphasis on using subject content as a vehicle to achieve general outcomes related to the personal development of learners?

#### **5.4 DO PRESERVICE TEACHERS VIEW THEIR PERSONAL THEORIES AS DEVELOPING OR COMPLETE?**

##### **Assertion Four**

Preservice teachers who are disposed towards reflecting on their practice are willing to change their personal theories of teaching and learning Mathematics to accommodate new experiences.

The majority of the Third Year students (60%) decided to change their initial metaphors in some way. Given that this entire group had originally suggested metaphors typical of simple theories of teaching, this was a progressive step. This willingness to change is also a reflection of the ethos in this group which was conducive to reflection and engagement with tasks.

In contrast, the majority of the Fourth Year students (63%) did not choose to amend their metaphors in any way. I regard this more as a reflection of their attitude towards their studies than a commitment to a particular viewpoint. I think that the timing of this activity had a great influence on this disappointing response. The Fourth Year students at the time of this activity had recently returned to college from their time in the schools during Teaching Practice. This is always a very stressful time for final year students as they need to apply for jobs and make decisions about their future. Many of the students were competing for the same jobs which led to tension in the group. Those who had secured employment for the following year did not seem to think there was much left to learn from College. The current situation in education meant that many students could not see themselves getting teaching employment which made the task of reflecting on their own teaching seem futile. All of this militated against reflection.

Even when the preservice teachers readily concede that their own school experience of Mathematics Teaching was less than ideal, suggestions for improvement were generally rather superficial. There is evidence of a strong belief in the “telling” method and the value of good clear explanations followed by individual practice. When this method fails to result in pupil learning, the preservice teachers were quick to identify the problem as inadequate explanation and/or lack of practice. The adherence to the basic principle and belief underlying the practice

remains firm. This was described by Francis (1997) as previously quoted, when she remarked that what teachers do and what they are able to see is so inscribed in their being that their implicit knowings are reconstituted under cover of different strategies.

I do not consider the direction of the change as important to the professional development of the preservice teachers as the willingness to change.

## 5.5 THE WAY FORWARD

As I write this, KwaZulu Natal teachers are faced with the reality that approximately half the candidates in the 1998 Matriculation examination failed to pass. Of more concern to teachers of Mathematics is the appalling news that 86% of the Standard Grade Mathematics candidates failed to obtain the pass mark of 33%. Many reasons are suggested for this state of affairs, but certainly there is no room for complacency on the part of teachers or teacher educators. Few could claim that effective learning occurred no matter what teaching was attempted. I am reminded of Fox's observation that "many a good cupful has been poured, but the cups are not very full" (Fox, 1983, p.152). Teaching has not been effective and it seems to be that some of the problem lies in the implicit beliefs of teachers that drive their practice and impede change and innovation.

The teachers' personal theories about teaching and learning Mathematics have their roots in their school experience as learners. Preservice Mathematics Education courses stand squarely between this experience and their schoolteacher experience, and so the onus is on the Mathematics Education course to make a difference. I consider it a task of a Mathematics Education course to promote the following four personal characteristics in preservice teachers.

### **Preservice teachers should feel challenged to make a difference**

Preservice teachers need to be challenged to make a difference. This occurs when a vision of something better is provided and enthusiasm is generated. This would require the ideas of many enthusiastic and innovative people to be widely circulated. Preservice teachers should be encouraged to put their beliefs on the table and to be open to challenge.

### **Preservice teachers should have a critical attitude**

Preservice teachers need to move away from an acceptance of things as they are. A questioning attitude that seeks good reasons for the status quo is important. This does not



imply a destructive negativism but rather a genuine attempt to understand why things are as they are and if this is necessarily the best or only way.

**Preservice teachers should be competent**

It is one thing to discern faults in the system but quite another to effect meaningful change. The latter requires sound subject matter competence, pedagogical skills to manage classrooms, lots of resources and the ability to create and adapt resources. In essence, the preservice teachers need to be thoroughly competent in all aspects of Mathematics Education by the time their course is completed. In addition, inservice training should be valued as a means of remaining competent.

**Preservice teachers should be confident**

With the competence discussed above, comes confidence - the self belief that affirms a person that he/she can do the task and do it well. This self confidence (always supposing it is well founded) sets a good tone for the classroom and promotes a positive learning environment. Confident and competent teachers are more likely to innovate and use creative learning methods.

These characteristics can be promoted in the formal curriculum. In addition, the prevailing ethos and enthusiasm of the facilitators in such courses contribute to the hidden curriculum which can have a great influence on the preservice teachers. In order to face the challenges of the new millenium, we need Mathematics teachers who critically examine the practice of Mathematics teaching, feel challenged to make a difference, and possess the confidence and competence to do so. Herein lies the challenge for Teacher Education institutions.

## REFERENCES

- Aguirre, J. M., & Haggerty, S. M. (1995). Preservice teachers' meanings of learning. *International Journal of Science Education*, 17(1), 119-131.
- Argyris, C., & Schön, D. A. (1974). *Theory in Practice : Increasing Professional Effectiveness*. San Francisco: Jossey - bass.
- Ball, D. L. (1988). *Research on Teaching Mathematics: Making Subject Matter Knowledge Part of the Equation*. Michigan: National Center for Research on Teacher Education.
- Bogdan, R. C., & Biklen, S. K. (1992). *Qualitative Research in Education*. (2nd ed.). Boston: Allyn and Bacon.
- Bougey, J. (1997). What do you actually mean by "learning"? : Unpublished.
- Bullough, R. V. (1991). Exploring Personal Teaching Metaphors in Preservice Teacher Education. *Journal of Teacher Education*, 42(1), 43 - 51.
- Bullough, R. V. (1994). Digging at the Roots: Discipline, Management, and Metaphor. *Action in Teacher Education*, XVI(1), 1-10.
- Bullough, R. V., & Gitlin, A. (1995). *Becoming a Student of Teaching*. (Vol. 2). New York: Garland Publishing.
- Calderhead, J. (Ed.). (1987). *Exploring teachers' thinking*. London: Cassell.
- Clark, C. (1995). *Thoughtful Teaching*. London: Cassell.
- Clark, C. M. (1992). Teachers as Designers in Self-directed Professional Development. In A. Hargreaves & M. Fullan (Eds.), *Understanding Teacher Development* (pp. 75-84). London: Teachers College Press.
- Clark, C. M., & Peterson, P. L. (1990). Teachers' Thought Processes. In M. C. Wittrock (Ed.), *Handbook of Research on Teaching* (3rd ed., pp. 255-296). New York: Macmillan.
- Davis, R. B. (1992). Reflections on where Mathematics Education now stands and on where it may be going. In D. A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 724-734). New York: Macmillan.
- Denzin, N. K., & Lincoln, Y. S. (1994). Introduction: Entering the Field of Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 1-17). Thousand Oaks: Sage Publications Inc.
- Erickson, F. (1998). Qualitative Research Methods for Science Education. In B. J. Fraser & K. G. Tobin (Eds.), *International Handbook of Science Education* (pp. 1155-1173).
- Fox, D. (1983). Personal Theories of Teaching. *Studies in Higher Education*, 8(2), 151-164.
- Francis, D. (1997). Critical Incident Analysis: a strategy for developing reflective practice. *Teachers and Teaching: theory and practice*, 3(2), 169-188.
- Gallagher, J. J. (Ed.). (1991). *Interpretive research in science education. NARST Monograph No. 4*. Manhattan: National Association for Research in Science Teaching.

- Gallagher, J. J., & Tobin, K. G. (1991a). Reporting Interpretive Research. In J. J. Gallagher (Ed.), *Interpretive Research in Science Education* (pp. 83-96). Manhattan: National Association for Research in Science Teaching.
- Hill, L. (1997). Just Tell us the Rule: Learning to Teach Elementary Mathematics. *Journal of Teacher Education*, 48(3).
- Janesick, V. J. (1994). The Dance of Qualitative Research Design: Metaphor, Methodolatry, and Meaning. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 209-219). Thousand Oaks: Sage Publications.
- Jofili, Z., & Watts, M. (1995). Changing Teachers' Thinking Through Critical Constructivism and Critical Action Research. *Teachers and Teaching: theory and practice*, 1(2), 213-227.
- Kroeze, J. W. C. (1989). *Teaching High School Mathematics*. Cape Town: Academica.
- Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: The University of Chicago Press.
- Lubisi, C., Wedekind, V., & Parker, B. (1997). *Knowledge, Curriculum & Assessment in South Africa: Learning Guide*. Pretoria: South African Institute for Distance Education.
- Mahlios, M., & Maxson, M. (1995). Capturing Preservice teachers' Beliefs About Schooling, Life, and Childhood. *Journal of Teacher Education*, 46(3).
- Manouchehri, A. (1997). School Mathematics Reform: Implications for Mathematics Teacher Preparation. *Journal of Teacher Education*, 48(3), 197-209.
- Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of Learning. *International Journal of Educational Research*, 19, 277-300.
- McDiarmid, G. W., Ball, D. L., & Anderson, C. W. (1989). *Why Staying One Chapter Ahead Doesn't Really Work: Subject-Specific Pedagogy*. Michigan: National Center for Research on Teacher Education.
- Miller, S. I., & Fredericks, M. (1988). Uses of metaphor: A qualitative case study. *Qualitative Studies in Education*, 1(3), 263-276.
- Munby, H. (1986). Metaphor in the thinking of teachers: An exploratory study. *Journal of Curriculum Studies*, 18, 197-209.
- Orton, A. (1987). *Learning Mathematics: Issues, Theory and Classroom Practice*. (2nd ed.). London: Cassell.
- Pajares, M. F. (1992). Teachers' beliefs and educational research : Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307-332.
- Reddy, M. (1978). The Conduit Metaphor; A case of frame conflict in our language about language. In A. Ortony (Ed.), *Metaphor and Thought* (2nd ed., pp. 164-201). Cambridge: Cambridge University Press.
- Richardson, J. T. E. (1999). The Concepts and Methods of Phenomenographic Research. *Review of Educational Research*, 69(1), 53-82.
- Rowntree, D. (1981). *Developing Courses for Students*. London: Harper & Row.
- Sfard, A. (1998). On Two Metaphors for Learning and the Dangers of Choosing Just One. *Educational Researcher*, 27(2), 4-13.

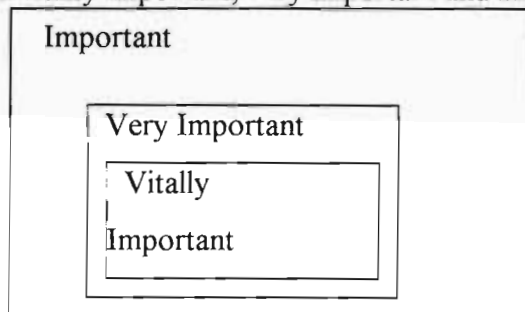
- Sinclair, J. (Ed.). (1993). *Collins Cobuild English Language Dictionary*. London: HarperCollins Publishers.
- Skemp, R. R. (1978). Relational understanding and instrumental understanding. *Arithmetic Teacher*, 26(3), 9-15.
- Smith, J. P. (1996). Efficacy and Teaching Mathematics by Telling: A Challenge for Reform. *Journal for Research in Mathematics Education*, 27(4), 387-402.
- Sticht, T. G. (1993). Educational Uses of Metaphor. In A. Ortony (Ed.), *Metaphor and Thought*. Cambridge: Cambridge University Press.
- Tann, S. (1993). Eliciting Student Teachers' Personal Theories. In J. Calderhead & P. Gates (Eds.), *Conceptualising Reflection in Teacher Development*. (pp. 53-69). London: The Falmer Press.
- Technical Committee On the Revision of Norms and Standards for Educators. (1998). *Norms and Standards for Educators*. Pretoria: Department of Education.
- Thompson, A. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics*, 15, 105-127.
- Thompson, A. G. (1992). Teachers' Beliefs and Conceptions: A Synthesis of the Research. In D. A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 127-146). New York: Macmillan.
- van Hiele, P. M. (1986). *Structure and Insight*. Orlando FL: Academic Press.
- Weinstein, C. S., Woolfolk, A. E., Dittmeier, L., & Shanker, U. (1994). Protector or Prison Guard? Using Metaphors and Media to Explore Teachers' Thinking about Classroom Management. *Action in Teacher Education*, XVI(1), 41-54.
- Zeichner, K. M., & Grant, C. K. (1981). Biography and social structures in the socialization of student teachers. *Journal of Education for Teaching*, 7, 298-314.

## APPENDIX A

### ACTIVITY ONE. OUTCOMES OF A MATHEMATICS EDUCATION COURSE.

The purpose of this free response activity was to determine whether the students perceived theories of teaching and learning Mathematics as significant in their preparation for teaching.

- Participants were initially asked to individually list five desirable outcomes of a Mathematics Education course and to fill these in the spaces provided on the Activity sheet. This elicited personal opinions and provided a record of the participants' first thoughts.
- These five outcomes were then written on small pieces of paper, which were collected, shuffled and redistributed to the participants so that each person had five outcomes to consider.
- Small groups of four or five students were formed. Each group was supplied with a poster with areas designated vitally important, very important and important.



- Each person in turn read out one outcome and placed it in what they considered to be the most appropriate area. This continued around the group without discussion until all the slips of paper were positioned. Any duplicates were removed.
- The group had then to discuss and negotiate the position of the slips of paper. No more than one quarter of the outcomes could be in the vitally important area and no more than one quarter could be in the important area. The group had to try to reach consensus.
- Once the positioning was agreed upon, the slips of paper were glued in position.
- Each individual participant was asked to fill in the final results of their group's discussion in a table on their individual Activity sheets. This then provided a written record of changes of opinion.
- The participants were then given an opportunity to provide comment on the group opinion in comparison to their own and to suggest amendments to their initial list. Finally comments and/or questions were invited.

Name: 4 SCA  
MATHEMATICS EDUCATION

## Outcomes of a Mathematics Education Course

This course is named Mathematics Education. I envisage us working together to develop into better mathematics educators. This is what I hope will be the general outcome of this course. In order to plan the course, we need some more specific outcomes - knowledge, skills and values that will be promoted by participation in this course.



### Individual Activity

What specific outcomes would you like to see for this course?

List five desirable outcomes :

1	
2	
3	
4	
5	

Copy these five outcomes onto the small pieces of blue paper provided.



### Small Group Activity

The slips of paper will be collected, shuffled and redistributed so that each person has five outcomes to consider. Each group is supplied with a poster with areas designated vitally important, very important and important.

Important
Very Important
Vitally Important

- Each person in turn reads out one outcome and places it in what they consider to be the most appropriate area.

This continues around the group without discussion until all the slips of paper are positioned.

- Any duplicates are removed.
- The group must discuss and negotiate the position of the slips of paper. No more than a quarter of the outcomes can be in the vitally important area and no more than a quarter can be in the very important area. The group must try to reach consensus.
- Once the positioning is agreed upon, the slips of paper are glued in position.



### Individual Activity

Copy your group's final result here.

Vitaly Important	Very Important	Important

- \* Do you have any personal reservations about this classification of the outcomes or about the actual outcomes?
- \* How does your initial list of five desirable outcomes compare with the ideas you read in your group? Would you now like to change your list?
- \* Do you have any comments or questions arising from this activity?

**APPENDIX B****ACTIVITY TWO****WHAT WOULD YOU DO IN THIS SITUATION?**

The purpose of this activity was to encourage participants to think about how they might react in three critical incidents and to try to account for differences among their fellow students, and for their own ideas.

- Participants were presented verbally, and in written form with a situation that might occur in a school and asked what they would do. Initially an individual written response was required.
- Once all participants had had an opportunity to respond, the debate was opened to the whole group and participants were asked to share their responses.
- Finally, individual participants were asked to reflect on the differences they may have found in their responses compared to others in the group, and to try to account for these differences.



Name: 4 SC  
MATHEMATICS  
EDUCATION

## What would you do in this situation?



### Individual Activity

Read the description of a situation that could arise in your classroom. Describe what you consider to be the best thing to do in this situation. Try to explain the thinking that prompts you to follow this course of action.

**Richie** is a pupil of average mathematical ability. He sits quietly in class and pays attention while you explain the work.

On Monday you explained carefully the process of completing the square, drawing attention to all the steps as you went along. A few able pupils were then called up to the board and they successfully completed some examples with a little help from you. The homework for Monday night was to do several similar examples.

You had planned Tuesday's lesson to include a brief review of the homework followed by examples involving the solution of quadratic equations using the completing the square technique. When Richie arrives on Tuesday, he is pleased to say that he has done all his homework. However a quick glance tells you that the work is totally incorrect.

## What would you do in this situation?

*Write a detailed response here.*

Name: 

4 SC  
MATHEMATICS  
EDUCATION

## What would you do in this situation?



### Individual Activity

Read the description of a situation that could arise in your classroom. Describe what you consider to be the best thing to do in this situation. Try to explain the thinking that prompts you to follow this course of action.

You are a junior teacher at a school and part of a large mathematics department. Your head of department would like all the teachers to use a self study programme for the section on congruent triangles. You duly issue the pupils with the programme and after a few days you receive the following letter.

Dear Ms Jones

I am approaching you on behalf of several of the parents of your pupils. We are most unhappy with the way in which you are approaching the Grade 9 mathematics this year. Our children are in the top group and we expect them to achieve well and to receive top class tuition.

Our children tell us that they are expected to work through the study guide themselves. When they ask you to teach them the work you say that it is more important for them to learn than for you to teach! We pay high school fees and are most unhappy with this attitude. Surely it is your job to explain the work to our children.

We trust that you will take steps to address our concerns.

Yours sincerely

Ivor Problem

(on behalf of the Grade 9 parents)

## What would you do in this situation?

*Write a detailed response here.*

Name: 4 SC  
MATHEMATICS  
EDUCATION

## What would you do in this situation?



### Individual Activity

Read the description of a situation that could arise in your classroom. Describe what you consider to be the best thing to do in this situation. Try to explain the thinking that prompts you to follow this course of action.

You are teaching a rather tricky section of the mathematics syllabus involving ratio and proportion and similar triangles. The learners are battling with the work. Jane brings you a problem her brother was given in a test at his school and suggests that the class try it. You commend her interest and give the problem to the class to try. While they are busy, you look at the problem and realise that you yourself are not sure how to do it, and after a few attempts you are at a complete loss as to how to solve the problem.

## What would you do in this situation?

*Write a detailed response here.*

4 SC

Name:

## What would you do in this situation ?



### Small Group Activity

Discuss with your responses with the other members of your group. Did your responses differ from the others in your group? Why do you think this is so?

**Richie's Story**

**Jane's Story**

**Ms Jones' Story**

**APPENDIX C****ACTIVITY THREE            METAPHORS FOR THE TEACHING AND LEARNING  
OF MATHEMATICS**

The purpose of this activity was to give preservice teachers the opportunity to try to capture the essence of their personal theories about the teaching and learning of Mathematics in the form of a drawn and described metaphor.

The activity was designed to be carried out in three stages, the first two as preparatory exercises ahead of the main task.

- The participants were shown six drawings representing metaphors for teaching and learning. Small groups of preservice teachers were asked to look at these and identify the teacher, the learners and the knowledge in each picture. Each group was then asked to identify the metaphor that they felt best conveyed what they believed about the teaching and learning of Mathematics, and the metaphor that they felt least conveyed what they believed about the teaching and learning of Mathematics. These were discussed with the entire group.
- The participants were given an Activity sheet headed “The Way Things Are” and asked to draw a picture that was a metaphor for teaching and learning Mathematics as they had experienced it. This may be as it was when they were at school, as it was when they did Practice Teaching in a school, or even as they have experienced it at tertiary level. Once all had had an opportunity to complete their drawings and to write a description of how it works, these were shared with the group.
- Lastly the participants were given another Activity sheet headed “ My Vision of the Way Things Ought to Be”. The task was to draw and explain a metaphor that expressed their vision of teaching and learning Mathematics in schools. The teacher, the learners and the Mathematical knowledge should be clearly identified. The way in which Mathematics is learned should be clearly explained and the fact that some learners do not successfully learn the Mathematics accounted for. Participants were encouraged to take the Activity sheet away and to give some considerable thought to the metaphor they chose.

Name:

## Metaphors for teaching and learning Mathematics

2 SCA  
MATHEMATICS EDUCATION



### Individual Activity

### The Way Things are .....

Draw a metaphor that you could use to explain how you see the teaching and learning of mathematics in the schools with which you are familiar. You must be able to clearly identify the teacher, the learners, and the mathematical knowledge. You should also be able to explain how the learning of mathematics occurs in your metaphor, and to account for the fact that some learners do not learn the mathematics successfully.

<u>Drawing</u>	<u>Explanation</u>

**Metaphors for teaching and learning Mathematics**  
**The way things are**

Name:

## Metaphors for teaching and learning Mathematics

2 SCA  
MATHEMATICS EDUCATION



### Individual Activity

### My Vision of the Way Things Ought to Be

Draw a metaphor that you could use to explain your vision of teaching and learning of mathematics in schools. You must be able to clearly identify the teacher, the learners, and the mathematical knowledge. You should also be able to explain how the learning of mathematics occurs in your metaphor, and to account for the fact that some learners do not learn the mathematics successfully.

<u>Drawing</u>	<u>Explanation</u>

**Metaphors for teaching and learning Mathematics**  
**My vision of the way things ought to be**

**APPENDIX D****INTERVIEWS WITH FOCUS STUDENTS**

The following key questions were posed to each preservice teacher interviewed:

1. Folk wisdom says that new teachers tend to "teach as they were taught". Can you describe to me how you were taught Mathematics at school?
2. Do you think that you will choose to teach in this way?
3. What sort of belief about the teaching and learning of Mathematics do you think led your teacher to teach in that way?
4. Do you think that your beliefs are different to those of that teacher?
5. Here is a copy of the metaphor you drew for the teaching and learning of Mathematics. Could you explain to me again how you feel that this describes teaching and learning?
6. Would you say that you have changed your beliefs about the teaching and learning of Mathematics since you left school? What caused this change?
7. Do you think you will be able to teach according to your beliefs during practice teaching? What might prevent you?
8. At the beginning of the Mathematics Education course, I asked you to suggest some possible outcomes for the course. Nobody at all thought it important to think about how they saw the teaching and learning of Mathematics. Now that we have done some work on your beliefs, would you think it important?



**APPENDIX E****READING ACTIVITY****PERSONAL CONCEPTIONS OF TEACHING AND LEARNING**

This activity was based on the following article:

Fox D (1983). Personal Theories of Teaching. *Studies in Higher Education*, 8(2), 151-163.

The Activity firstly required the preservice teachers to read through the article carefully and then to summarise the main features of each idea about teaching in a table provided on the Activity sheet. Following on from the reading, the participants were posed the following question.

- Suppose you looked in through a Mathematics classroom window and watched a teacher at work. Describe how you think you could tell which of the beliefs about teaching is held by that teacher. This would involve describing what the teacher is doing and what the learners are doing.

A table was provided for the participants to fill in possible activities for both teachers and learners in the case of teachers subscribing to transfer, shaping, travelling and growing theories respectively.

Finally, the preservice teachers were given the opportunity to discuss their ideas with other members of a small group and to see whether they differed in any way in the evidence they would look for. Participants were also asked whether they thought it possible that a teacher could hold different beliefs and operate according to different theories depending on the occasion.

Name: 

4 SC MATHEMATICS EDUCATION
----------------------------------

## PERSONAL CONCEPTIONS OF TEACHING AND LEARNING

This activity is based on the following article:

Fox D (1983) *Personal Theories of Teaching*. *Studies in Higher Education* Vol 8 No. 2  
pp151 - 163

In this article, Dennis Fox identifies four different categories of conceptions or theories of teaching. These are ideas that students and lecturers in Higher Education have expressed. It is interesting to see how similar these theories are to the conceptions we hold or recognise in others.



### Individual Activity

- Read through the article carefully.
- Summarise the main features of each idea about teaching in the table below.

Transfer Theory	
Shaping Theory	
Travelling Theory	
Growing Theory	

- Suppose you looked in through a mathematics classroom window and watched a teacher at work. Describe how you think you could tell which of the beliefs about teaching is held by that teacher. This will involve describing what the teacher is doing and what the learners are doing.

	Teacher	Learners
Transfer Theory		
Shaping Theory		
Travelling Theory		
Growing Theory		



### Small Group Activity

- Discuss your ideas relating to the practice of teachers holding the different beliefs about teaching. Are there any differences in the evidence you would all look for?
- Do you think it is possible that a teacher could hold different beliefs and operate according to different theories depending on the occasion?

**APPENDIX F**  
**PRACTICAL TEACHING BASED ON PARTICULAR CONCEPTIONS OF**  
**TEACHING AND LEARNING**

Like the reading activity that precedes it, this activity was based on the following article:

Fox D (1983). Personal Theories of Teaching. *Studies in Higher Education*, 8(2), 151-163.

In addition to the article, a summary table of the different theories prepared by Fox was made available.

Each small group was allocated one of two Mathematics topics that are taught in the secondary school. In addition they were given a sealed envelope containing the theory of teaching that they would espouse for the purpose of this activity.

The task was to prepare a presentation outlining a teaching sequence and approach to the topic that the group felt would be typical of a teacher with the given idea about teaching. The group was also required to prepare a written outline of their presentation, and be able to show how each of the parts was consistent with the theory they were portraying. The thinking behind the various activities planned for the learners should have been made clear.

The remainder of the class attempted to identify, from the presentation, the theory being portrayed.

## PRACTICAL TEACHING BASED ON PARTICULAR CONCEPTIONS OF TEACHING AND LEARNING

This activity is based on ideas found in the following article:

Fox D (1983) Personal Theories of Teaching. *Studies in Higher Education* Vol 8  
No. 2 pp.151 - 163



### Small Group Activity

Each small group will be allocated one of three mathematics topics from the secondary school learning programme. In addition they will be given a sealed envelope containing the theory of teaching that they will espouse for the purpose of this activity.

The task is to prepare a presentation outlining a teaching sequence and approach to the topic that the group feels would be typical of a teacher with the given idea about teaching. The remainder of the class will attempt to identify from the presentation, the theory being espoused. For this reason it is essential that the contents of your groups' envelope remain confidential and known only to your group!

A summary table of the different theories prepared by Fox is available.

The group must prepare a written outline of their presentation, and be able to show how each of the parts are consistent with the theory they are portraying. In other words, we are trying to understand the thinking behind the various activities planned for the learners.

It is not envisaged that the presentations will be longer than ten minutes. Although some examples may be necessary in order to describe the planned activities, no worksheets or classroom ready materials need to be prepared. It is most important that the general teaching plan for the series of lessons is clearly described. All members of the group must participate in the presentation.

The lecture period on Tuesday 28 April is set aside for your continued preparation and for a brief progress report to me. The presentations will be on Tuesday 5 May. The order of presentation will be determined by ballot.

**APPENDIX G**  
**METAPHORS FOR TEACHING AND LEARNING MATHEMATICS**  
**(A SECOND LOOK)**

This activity provided an opportunity for the preservice teachers to reconsider their original metaphors for teaching and learning Mathematics.

The written activity required the preservice teachers to reread their original descriptions of metaphors for the teaching and learning of Mathematics and to consider whether their experience during Practice Teaching supported or challenged this metaphor.

Following on from this were questions as to whether their personal theories had changed in any way, what they thought might cause their theories to change, and whether indeed they considered it important that a teacher had a well thought out personal theory. Finally the preservice teachers were invited to draw and describe a reconsidered metaphor if they had changed their personal theory in any way.



Name:

## Metaphors for teaching and learning Mathematics

2 SCA  
MATHEMATICS EDUCATION  
ACTIVITY THREE

### Individual Activity

### My Vision of the Way Things Could Be - Reconsidered Version

Draw a metaphor that you could use to explain your vision of teaching and learning of mathematics in schools. You must be able to clearly identify the teacher, the learners, and the mathematical knowledge. You should also be able to explain how the learning of mathematics occurs in your metaphor, and to account for the fact that some learners do not learn the mathematics successfully.

<u>Drawing</u>	<u>Explanation</u>

Metaphors for teaching and learning Mathematics  
My vision of the way things could be - reconsidered version

## Metaphors for teaching and learning Mathematics ( a second look ! )

In March this year you drew and described a metaphor to explain how you view the teaching and learning of Mathematics - your own personal theory. Since then, we have discussed various other ideas, especially those suggested by Dennis Fox (transfer, shaping, travelling and growing theories). In addition, you have recently spent five weeks at a school doing practical teaching. You were asked to keep your original metaphor in mind during this time.

- \* Reread your original personal theory of how mathematics teaching and learning should be.
- \* Did your experience during teaching Practice support or challenge your metaphor? Try to provide specific examples.
- \* Have you changed your personal theory in any way?
- \* What do you think would cause you to change your personal theory?
- \* Do you think it is important for teachers to have a well thought out personal theory of mathematics teaching and learning ?
- \* If you have changed your belief in any way, draw and describe your amended metaphor for the teaching and learning of Mathematics.



**APPENDIX H**  
**LETTER REQUESTING PERMISSION TO USE PRESERVICE TEACHERS' WORK**  
**FOR THIS STUDY**

This is a copy of the letter given to each preservice teacher, informing them of the study which I was undertaking, and giving them the option to withdraw their work from the data pool.

Permission to use work done in Mathematics Education  
for Research Purposes

I have been very interested in the ideas you have expressed in the Mathematics Education Course and have enjoyed reading your responses to the various classroom situations, looking at the metaphors you created to explain your own ideas about the teaching and learning of Mathematics and watching you trying out some of the teaching theories described in the literature.

I am keen to use the work that you have done as a basis for a dissertation I am required to prepare as part of a Masters Degree in Tertiary Education. I am especially interested in the beliefs that pre-service teachers hold about mathematics teaching and learning and how those beliefs change over time. No student will be identified by name in the dissertation so that your opinions will remain confidential.

If for some reason you do not wish your work to be included in my project, please indicate this to me and I will disregard your work.

Your co-operation will be much appreciated.

S.D. HOBDEN  
Edgewood College of Education  
May 1998.

## TABLE OF CRITERIA FOR THE CLASSIFICATION OF PERSONAL THEORIES

TABLE A1 CRITERIA FOR CLASSIFICATION OF PERSONAL THEORIES

	TRANSFER THEORY	SHAPING THEORY	TRAVELLING THEORY	GROWING THEORY
Verbs commonly used	Convey, impart, implant, imbue, give, expound, transmit, tell, put over, get across, explain  Refers to subject matter	Develop, mould, demonstrate, produce, instruct, condition, prepare  Refers to learner	Lead, point the way, guide, initiate, help, show the way  Refers to subject matter	Cultivate, encourage, nurture, develop, foster, enable, bring out, help  Refers to learner
The subject matter	Commodity to be transferred. Originates from within the teacher	Shaping tools, pattern, blue print, recipe Exists independently of teacher but requires implementation	Terrain to be explored. vantage points. Focus on the subject matter as object of study	Experiences to be incorporated into developing personality. Actual content not of prime importance, but effect
The learner	Container to be filled. person or animal to be fed.	Inert material ( clay, wood, metal) to be shaped.	Explorer	Developing personality, growing plants
The teacher	Pump attendant, food processor, tap, clouds full of rain	Skilled craftsman working with raw material, or selecting and assembling components.	Experienced and expert travelling companion. Guide. Provider of travelling aids.	Resource provider. Gardener
Teacher's Status	Dominant	Dominant	Co-learner and facilitator	Facilitator and mentor
Standard teaching methods	Lectures, reading lists, duplicated notes.	Demonstrations and explanations followed by supervised practice of set procedures. Exercises with predictable outcomes.	Simulations and projects. Self study assignments and investigations with unpredictable outcomes. Open questions and discussions.	Experiential methods similar to the travelling theory but less structured and more spontaneous. Content derived from learner responses.
Explanation of failure to learn	Leaky vessels, small container. poor transfer skills, poor aim.	Flawed, faulty raw material. Incompetent craftsman. Poor or missing blue print.	Blinkered vision, lack of stamina. Unadventurous and lethargic learners. Poor guides, poor equipment, restrictions on the route.	Poor start, inadequately prepared, no will to develop. Restricted diet, unsuitable food. Incompetent gardener.