

**Primary Teachers' Affective Development in Mathematics:  
Developing positive beliefs, attitudes and feelings**

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## Chapter 1: Introduction

Primary school teachers are generally required to teach all of the curriculum disciplines, and therefore they are all teachers of mathematics. However, teachers' attitudes to and confidence with the teaching of mathematics can vary considerably (Biddulph, 1999; Joram & Gabriele, 1998; McLeod, 1992; Schuck, 1996). Preservice teachers have had many experiences of mathematics during their own schooling which are likely to have influenced their beliefs, values and feelings about mathematics. The commencement of their teacher education provides another range of experiences in mathematics, both in lectures and during practicums, and these can also impact on preservice teachers' beliefs and feelings about mathematics (Cooney, Shealy & Arvold, 1998). The beliefs, values, attitudes and feelings of preservice teachers can in turn, influence their confidence and efficacy in teaching mathematics. Their reflection upon these affective factors is an important part of their development as teachers, and in particular, their teaching of mathematics (Thompson, 1992).

### *Affective Dispositions Toward Mathematics*

In 1997 a university academic from a discipline other than mathematics gave the opening address for the New Zealand Association of Mathematics Teachers conference. To an audience of some 500 mathematics teachers she proudly declared that she was "no good at maths". It seemed that she was confirming the common perception that many people, even highly intelligent people, are poor at mathematics and they are willing to declare it publicly! Carroll (1994a, p. 131) commented that "many people seemed to be constrained by negative attitudes, beliefs and feelings about mathematics and mathematics learning." Indeed, it appears that for many people mathematics has negative connotations, and as such this attitude constitutes a significant problem.

Research suggests that primary school teachers often share these negative perceptions of mathematics, and their views can influence their teaching of mathematics (Bobis & Cusworth, 1994; Schuck, 1997a, 1997b). Further to these

negative feelings, they can also have strong, well-established beliefs about mathematics that may significantly influence their mathematical pedagogy (Ball, 1990). Thompson (1992) suggested that a traditional view of mathematics predominated amongst preservice and inservice teachers - they viewed mathematics in either an absolutist or instrumental fashion even when their mathematics education courses had provided contrasting philosophies and approaches. These beliefs about the nature of mathematics were then commonly enacted in their teaching practice, which was characterised by exposition, practice and rote-learning (Mayers, 1994). Schuck (1996) commented that "... the work of primary school teachers in mathematics is generally seen to differ from their work in other subject areas; mathematics is transmitted ..." (p. 119). Cooney, et al. (1998, p. 310) noted that some teachers' mathematical pedagogy was inconsistent with their beliefs about mathematics:

... it is quite possible for teachers to simultaneously hold that problem solving is the essence of mathematics and that students best learn mathematics by taking copious notes and memorising what is to be learned.

As with the views of teachers in general outlined above, studies into the mathematical beliefs of preservice teachers reveal absolutist and instrumentalist views as almost universal (Cooney, et al., 1998; Mayers, 1994; Schuck, 1997a, b). The impact of these beliefs on mathematical pedagogy can be significant, as they mitigate against the development of mathematics as a human endeavour within a fallibilistic epistemological framework. The net result appears to be that prospective primary teachers have views about mathematics and the teaching of mathematics that are often narrow (Schuck, 1997b) and enacted through a transmission model of teaching (Biddulph, 1992).

The research literature on preservice primary teachers' affective dispositions towards mathematics suggests that this group also holds views about mathematics and mathematics teaching which may not be conducive to quality learning. Grootenboer (2000) reported that almost 70 percent of the primary student teachers surveyed held negative attitudes towards mathematics, and Biddulph (1999, p. 66) found "... between one-half and two-thirds [of the teacher education students] had distinctly negative feelings about the subject." The students in the negative group articulated emotions that included lacking enthusiasm,

nervousness, fear, “feeling a total failure”, terrified, intimidated and hatred. In Carroll’s (1994a) case study where she researched the “mathphobia” of one preservice teacher, she noted that her lack of confidence and her destructive feelings about mathematics made it difficult for her to learn basic mathematical ideas, let alone teach it in a meaningful way. Indeed, if this finding has any generalisability, then there is great cause for concern.

### *The Issue*

The general theme in the research literature on teachers’ affective dispositions towards mathematics is one of negativity. This may be reason enough for the current project which aims to explore preservice primary teachers’ beliefs, attitudes, feelings and values about mathematics education, and in particular, the impact their experiences have had on the development of these dispositions. Many have suggested that a negative affective disposition towards mathematics leads to restricted and hindered mathematics teaching and learning (Mayers, 1994; Relich & Way, 1992). There is a need to know the ways in which preservice teachers can alter their perceptions and attitudes to reflect more positive beliefs and constructive attitudes (Ball, 1990; Bobis & Cusworth, 1994). Furthermore, there is a need for research into the experiences that make a difference in their teacher education in terms of developing their confidence in teaching mathematics (Carroll, 1994b; Mayers, 1994; Schuck, 1996). Because of evidence suggesting that a cycle of negative perception exists it would appear that there is an urgent need to address these issues if mathematics educators are to *break this cycle* of negativity (Ball, 1990; Mayers, 1994).

### *The Cycle of Negativity*

Ball (1990) notes that being anxious about mathematics does not endear a teacher to the teaching of the subject. In commenting on the development of feelings (like anxiety), attitudes and beliefs about mathematics, she highlighted the cyclic problem that:

Prospective teachers are ... unlikely to acquire an appropriate view of the discipline as a result of precollege mathematics experience. The view they hold is likely to shape not only the way they teach mathematics once

they begin teaching but also the way in which they approach *learning to teach* mathematics: A vicious cycle emerges. (Ball, 1990, p. 463)

It is possible to trace a cycle of teacher beliefs, attitudes and feelings, which impact upon their pedagogical practices (see Figure 1.1). These, in turn, significantly influence the development of their students' beliefs, attitudes and feelings. Some of these students then pursue teaching as a career, returning to the start of the cycle, and all become members of society that contribute to the development of mathematical views of others in their community (e.g., parents with their children).

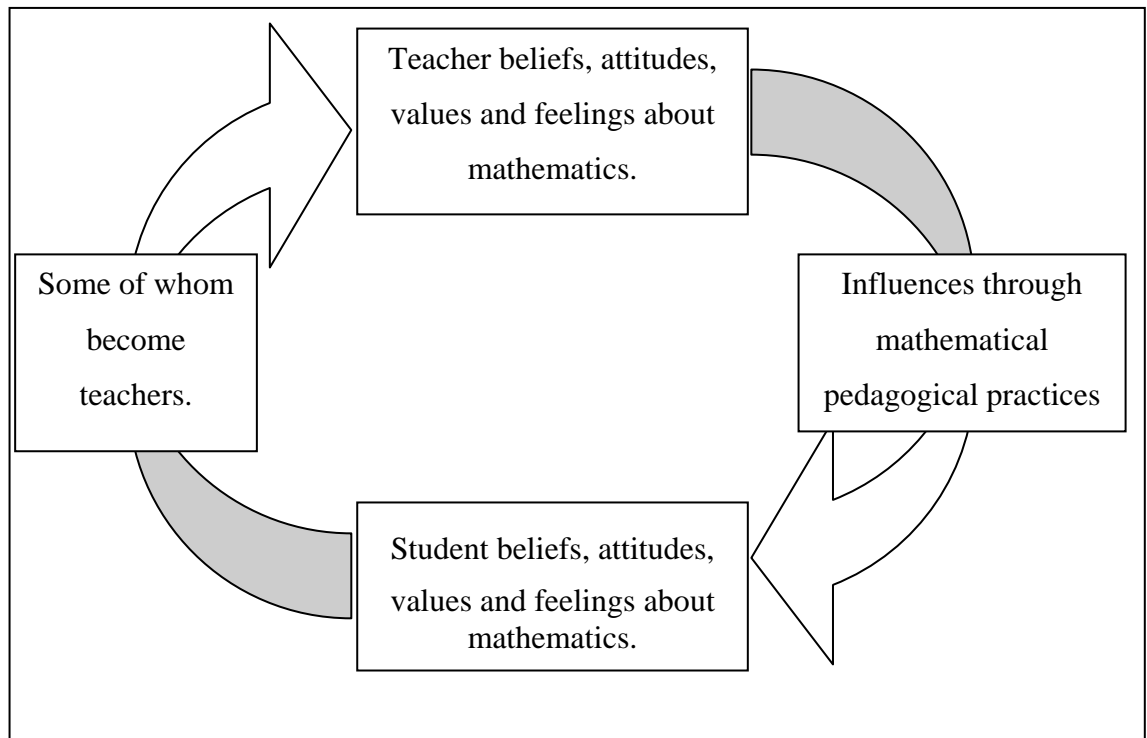


Figure 1.1: Cycle of affective views of mathematics amongst teachers.

This cycle has been noted by a number of authors (Ball, 1990; Davies & Savell, 2000; Mayers, 1994; Relich & Way, 1992) with some concern, and although there is some consensus on the need for it to be broken, there is less certainty about how it might be done.

Most mathematics educators believe that along with proficient mathematical knowledge and understanding we would want students to have a positive disposition towards the subject. Relich and Way (1992, p. 460) commented that,

“although there is little hard evidence that holding positive attitudes towards mathematics is actually beneficial, it is difficult to argue against their desirability”. Similarly, many statements on mathematics education reflect the need for students to develop positive views of mathematics, as is illustrated with the following extract from *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992, p. 8):

Mathematics education aims to help students to develop a belief in the value of mathematics and its usefulness to them, to nurture confidence in their own mathematical ability, to foster a sense of their personal achievement, and to encourage a continuing and creative interest in mathematics.

If indeed, mathematics education is to be released from negative cyclic development of attitudes, beliefs, values and feelings, then it needs to be overtly addressed and carefully researched. This study set out to explore the participants’ affective responses to mathematics in order to better understand how these responses developed and what might be done to bring about positive change.

## **Organisation of the Thesis**

Chapter Two of this report outlines literature on the affective domain particularly as it relates to mathematics education. It explores prior research and literature on the impact of affective factors on teachers and teaching, and it also discusses teachers’ experiences of mathematics and how they influence affective views of the subject.

The methodology and methods of the study are outlined in Chapter Three, and the findings are presented in Chapters Four to Six. Chapter Four reports on the quantitative data, Chapter Five outlines the qualitative data and Chapter Six presents some case studies and stories that capture the essence of the data in narrative form.

There is a detailed discussion of the findings in Chapter Seven, which draws together the data of the previous three chapters, and then the report closes in Chapter Eight with some conclusions and recommendations.

## **Chapter 2: Literature Review**

### **Introduction**

Mathematics education appears to be faced with a major problem in that many people seem to be constrained by negative attitudes and feelings about the subject (Carroll, 1994b). Furthermore, mathematics is often viewed as a narrow, irrelevant subject which has little connection to real-life (Thompson, 1992). It has been suggested that most of these beliefs, values, attitudes and feelings have developed at school in mathematics classes and if this is the case, there are some significant issues for mathematics educators to address.

This literature review explores the background areas related to the present study and draws on literature from psychological, general education and mathematics education sources. It comprises four main sections. Initially the affective domain and its various components will be explored drawing on theoretical views and prior research. Although there is a distinct connection between the affective and cognitive domains, this study has been limited to the affective area and therefore, little attention is given to cognition. However, there is a particular focus on affective aspects in the context of mathematics education. This sets a foundation for the subsequent sections where the reciprocal influences of affective factors and mathematical experience are discussed. The second section addresses the impact of affective factors on teachers and teaching, and in particular the teaching of mathematics. Conversely, the third section discusses experiences of mathematics and how they influence beliefs, values, attitudes and feelings about the subject. Finally, a theoretical framework for understanding the learning and development of affective views about mathematics is presented. This section provides a theoretical basis for the discussion of the participants' affective development throughout the study.

## **The Affective Domain**

The affective domain has various inter-related components that are often ill-defined and confused in their meaning. According to McLeod (1992, p. 576), “the affective domain refers to a wide range of beliefs, feelings, and moods that are beyond the domain of cognition”. Even the distinction between the affective and cognitive domains is often unclear. He commented on the problem of a lack of clarity in the terminology used to describe the various subsets of the affective domain, suggesting that it needs attention from mathematics education researchers. In this study the affective domain will include the following inter-related facets:

- beliefs,
- values,
- attitudes, and
- feelings.

Whilst these aspects are dealt with separately in this review, the study itself will address them together. A number of studies have addressed subsets of the affective domain in regard to mathematics education, but the richness and complexity of the domain as a whole renders this division problematic (Owens, Perry, Conroy, Geoghegan & Howe, 1994).

### *Beliefs*

The significant place of beliefs in forming and defining teaching practice has been extensively reported (Artzt, 1999; Ball, 1990; Cooney, et al., 1998; Davis, 1999; Gondoseputro, 1999; Joram & Gabriele, 1998; Kagan, 1992; Mayers, 1994; McLeod, 1992; Nespor, 1987; Owens, Perry, Conroy, Geoghegan & Howe, 1998; Pajares, 1992; Pintrich, 1990; Schuck, 1997a; Schuck & Foley, 1998; Shield, 1999; Southwell & Khamis, 1992; Thompson, 1992; Tillema & Knol, 1997b; Tracey, Perry & Howard, 1998; Van Zoest, Jones & Thornton, 1994). However, what is not so clear is the meaning or definition of the concept of beliefs:

All teachers hold beliefs, however defined or labelled, about their work, their students, their subject matter, and their roles and responsibilities, but a variety of conceptions of educational beliefs has appeared in the literature. (Pajares, 1992, p. 314)



As noted by Pajares, the literature presents a range of definitions and conceptualisations of teachers' beliefs. After reviewing the definitions of anthropologists, social psychologists and philosophers, Richardson (1996, p. 103) noted that, "there is considerable congruence of definition among these three disciplines in that beliefs are thought of as psychologically held understandings, premises, or propositions about the world that are felt to be true". Furthermore, Rokeach (1968) suggested that beliefs must be inferred because they cannot be directly observed. Because there are likely to be both tacit and known compelling personal and social reasons, what an individual states may be quite different from their actual beliefs. The relative inaccessibility of beliefs and their tacit nature have in part led to a range of views and conceptualisations about beliefs (Macnab & Payne, 2000). However, common features of these meanings include the subjectivity of beliefs as personal assumptions of truth which act as predispositions to action (Rokeach, 1968). Also, it was commonly accepted that beliefs are structured and organised into some form of system (Green, 1971; Rokeach, 1968; Stuart & Thurlow, 2000).

Green (1971) suggested that there were three dimensions to belief systems; (1) primary and derivative beliefs; (2) central and peripheral beliefs; and (3) beliefs are often held in groups or clusters. Primary beliefs are developed from direct experience whereas derived beliefs are learned indirectly from "reference groups or people" (Rokeach, 1968, p. 5). Primary beliefs are considered to be more important and influential than derived beliefs. Secondly, beliefs can be organised along a central-peripheral continuum, where central beliefs have greater significance and impact, and they are more resistant to change (Andrews, 2000). According to Rokeach (1968), a central belief is developed from direct experience of the object of the belief, and it is then reinforced by social group consensus. As such, central beliefs are often primary beliefs. The third dimension of a belief system is the clustering of beliefs into relatively independent groups (Thompson, 1992). Green (1971) doubted the appropriateness of considering single beliefs, suggesting that all beliefs are overtly apparent in clustered systems. This clustering of beliefs into more or less isolated groups can help explain why it is

possible for people to hold apparently contradictory beliefs in different contexts (Richardson, 1996).

As intimated above, beliefs are formed either through direct experience of a phenomenon or, as a derivative of others' beliefs (Rokeach, 1968). Hill (2000b, p. 51) saw "... beliefs as historically and culturally conditioned and significantly influenced by social and motivational factors". The beliefs formed through direct experience are more central, and as such they are the most influential and powerful beliefs. Lortie (1975) suggested that teachers learn many of their beliefs about teaching through their years of experience in classrooms as students. His often cited concept of an *apprenticeship of observation* is used to explain the primary, central beliefs that many teachers hold, even before they begin their tertiary teacher education (Raths, 2001; Richardson, 1996). The general consensus in the literature is that these beliefs are difficult to change.

The process of changing beliefs is not well understood, and although it can occur, it is not necessarily in intended or desirable ways (Tillema, 2000). For an individual, belief change involves an individual deserting the familiar for the unknown and therefore, it is often difficult and challenging (Haggarty, 1995; Stuart & Thurlow, 2000). Hill (2000b) theorised about the conditions necessary for beliefs to change:

First, learners must be aware of and dissatisfied with their current conceptions and see that the new idea is intelligible and plausible and that taking it on is a fruitful proposition. Before accepting that change is necessary, learners must have first lost faith in the capacity of their current conceptions to solve their current problems. Second, they must be able to understand the new ideas. Third, they must believe that the new ideas will solve the problem. Fourth, they must believe it worthwhile to put time and effort into learning the new ideas. (pp. 51-52)

Whilst these ideas seem somewhat plausible, their cognitive flavour implies a logical and reasoned approach to belief change. Others have suggested that belief change does not occur through reasoning and logic, but rather when dissonance is aroused (Raths, 2001; Stuart & Thurlow, 2000). Although this point is partly addressed in Hill's quotation above when she spoke of a loss of faith, it does not give it the central role recommended by others. Because central beliefs have been

developed through experience, reflection upon that experience is critical to belief change (Pajares, 1992; Tillema, 2000).

Some researchers have suggested that belief change can occur gradually in an incremental process (Nisbet & Warren, 2000), but more prominent is the view that it is akin to a conversion or gestalt shift (Andrews, 2000; Richardson, 1996; Stuart & Thurlow, 2000). In common to both views, however, was the need to address experience and practice issues, because belief change requires reviewing the episodes which gave rise to the beliefs, and creating new experiences where the desirable belief was successful. Belief change will not occur simply through the presentation of new, desirable beliefs. The complex nature of beliefs belies a simple, linear, logical approach to belief change, and therefore, issues of memory, practice, emotion and thought need to be attended to in the process of belief change (Tillema, 2000).

#### *Teachers' Beliefs about Teaching, Mathematics, and Teaching Mathematics*

Preservice and inservice teachers' beliefs were frequently characterised as *personal assumptions* that were often tacitly or unconsciously held (Artzt, 1999; Joram & Gabriele, 1998; Pajares, 1992). These assumptions were generally about three broad issues; (1) teaching, learning and the educational process; (2) the nature of the subject matter (e.g., mathematics); and (3) ways of teaching and learning the subject material (Artzt, 1999; McLeod, 1992; Thompson, 1992).

In reviewing the research on preservice teachers' beliefs, Stuart and Thurlow (2000) highlighted the significant impact of their apprenticeship of observation as a student at school. They suggested that student teachers' beliefs ; (1) are formed early and resistant to change; (2) act as a filter to new information causing beliefs to be reinforced rather than challenged; (3) are not recognised as important; and (4) give primacy to the practical and the utilitarian. They concluded that, "preservice teachers have erroneous and simplistic beliefs about what it takes to be a successful teacher" (p. 114). Commonly, the preservice teachers in their study viewed teaching as simply a process of transmitting knowledge and dispensing information. Indeed, this poses a particular challenge for teacher educators, and this will be discussed further in a later section. Apart from

teachers' views about pedagogy in general, their beliefs about the subject matter were also significant (Thompson, 1992).

In mathematics education, the nature of the subject matter has been called "mathematical epistemology" (Schoenfeld, 1989), and it refers to the beliefs about the nature of mathematical knowledge. Ernest (1989) identified three conceptions of mathematics;

- (1) mathematics as an expanding field of human invention which is dynamic and problem-driven (Problem-solving view);
- (2) a structured, unchanging body of knowledge (Platonist view); and
- (3) mathematics as a collection of procedures, facts and skills (Instrumentalist view).

The traditional view of mathematics reflects primarily the Platonist view, but mathematical philosopher Hersh (1985) suggested it was appropriate to review this perspective so that features of mathematics that had been ignored might now be observed. He suggested that "mathematical knowledge is fallible, corrigible, tentative and evolving as is every other kind of human knowledge" (p. 10).

The mathematical epistemology of preservice and inservice teachers has commonly been described in absolutist (Platonist) and instrumentalist terms (Mayers, 1994). They tend to view mathematics as a set of rules, skills and procedures that are memorised without understanding, and as a subject with right and wrong answers which only the brightest people could understand (Sowder, 2001; Stipek, Givvin, Salmon & MacGyvers, 2001). A typical research finding was that of Aldridge and Bobis (2001) who found that their participants had a traditional view of mathematics as content driven. Frequently they described mathematics as "pure procedure" and as a subject that was characterised by right/wrong answers, memorising formulae and rote learning procedures. Certainly there were no research reports found in which teachers viewed mathematics as a human activity or construct which was fallible in nature, but rather, it was regarded as pre-existing and absolutely true (Ball, 1990; Cooney, et al., 1998; Joram & Gabriele, 1998; McLeod, 1992). The consensus seems to be that that these absolutist views of mathematics are not conducive to quality

mathematics education (Beswick & Dole, 2001; Lloyd & Frykholm, 2001; Stipek, et al., 2001)

Teachers' beliefs about the nature of mathematics and mathematical pedagogy are related to their beliefs about students and the social context of mathematics education. Furthermore, the school and community will often have strong views on the nature and style of mathematics education that will shape and constrain the beliefs and practices of the teacher. Commonly, teachers view their students in mathematics classes as *empty vessels that need to be filled* with mathematical knowledge (Ernest, 1989). This belief in turn, has implications for how mathematics is taught.

The above review of teachers' beliefs about mathematics has clear implications for their beliefs about teaching and learning mathematics. Kuhs and Ball (1986, p. 2) noted four main views on the pedagogy of mathematics; (1) learner-focussed; (2) content-focussed; (3) content-focussed with an emphasis on performance; and (4) classroom-focussed. They suggested that the learner-focussed belief is most sympathetic to constructivist notions of learning, whereas the second and third views are more akin to a behavioural theory of learning. The view of mathematics teaching that is classroom-focused is not associated strongly with a particular theory of learning, but rather on beliefs about the structure of the classroom environment and schools. A number of researchers suggest that it is the content-focussed views that currently prevail in the teaching of mathematics, and it is commonly characterised as *teaching by telling* (Buerk, 1985; Mayers, 1994; McLeod, 1992; Thompson, 1992). In discussing the findings of their longitudinal study on teachers' beliefs about mathematics education, Stipek, et al. (2001) found from their factor analysis that five dimensions of beliefs were strongly inter-related: (1) mathematics is a set of operations to be learned; (2) students' goal is to get correct answers; (3) the teacher is responsible for directing all facets of the mathematics activities; (4) mathematics ability is a fixed construct; and (5) students are motivated to engage in mathematics through extrinsic rewards and grades. These dimensions address the three broad areas identified earlier, namely beliefs about teaching and learning, beliefs about mathematics, and beliefs about the teaching and learning of mathematics. It also highlights the complex inter-

relationship between these factors, where each set of beliefs impacts upon the others.

Beliefs play a filtering role for new information, and as such, they play a moderating role for knowledge about teaching and learning mathematics (Gondoseputro, 1999; Joram & Gabriele, 1998; Nespor, 1987; Pajares, 1992). If the beliefs of preservice and inservice teachers are not conducive to effective mathematics teaching, then it is imperative to address them in some way. However, if beliefs are to be changed, then not only does the substance of the beliefs need to be explored, but also how they are developed and held (Cooney, et al., 1998). Nespor (1987) conducted a significant review of “the role of beliefs in the practice of teaching”, and she suggested that affective factors such as moods, emotions and feelings have a far greater impact on the development of beliefs than does knowledge and cognition. Further to this, beliefs are stored in episodic memory, couched in significant events in individual’s personal experience. Nespor (1987) suggested that, “... the affective and emotional components of beliefs can influence the ways events and elements in memory are indexed and retrieved and how they are reconstructed during recall” (p. 324). This implies that emotion and affective factors are an important aspect of how teachers learn and use what they learn. Furthermore, because of the way beliefs are developed and held, they may not be responsive to change through cognitive strategies such as critical evaluation, external examination and logical review. Perhaps this is why many writers have commented on the strength and permanency of teachers’ beliefs, and the difficulty in changing them (Joram & Gabriele, 1998; McLeod, 1992; Pajares, 1992; Thompson, 1992). The statement below is indicative of this dilemma:

... prospective teachers’ perceptions of and orientations to the knowledge they are presented with may be shaped by belief systems beyond the immediate influence of teacher educators. The development of beliefs over time, as a product of teachers’ long-term comprehension of different contexts for teaching would appear to be similarly difficult to predict, control, or influence. (Nespor, 1987, p. 326)

Whilst this may appear to be an insurmountable problem, Joram and Gabriele (1998) nonetheless offer some hope that the apparent obstacles of preservice teachers’ prior beliefs can become opportunities for transformation.

## *Values*

According to Rokeach (1973), the value concept is highly significant in education and worthy of exploration. Indeed, a number of writers have suggested that all education is value-laden (Bishop, FitzSimons, Seah & Clarkson, 1999; FitzSimons, Seah, Bishop, & Clarkson, 2001; Palmer, 1993; Rokeach, 1973). Rokeach defined a value as, “an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence” (p. 5). Values have also been described as the criteria by which people choose and assess other people, actions and events (Sowder, 2001). Furthermore, Rokeach (1973) suggested that values are organised in sets or clusters, and action is influenced by multiple values or value clusters as opposed to individual, isolated values.

Although there has been interest in values in education generally, values are a relatively new field of inquiry in mathematics education, and pioneering work has begun with Bishop, Clarkson and their colleagues in Melbourne, Australia in the *Values and Mathematics Project (VAMP)* (Bishop, et al., 1999). They rightly point out that education in general, and specifically mathematics education, is value-laden, and therefore, worthy of attention. They suggested that “values in mathematics education are the deep affective qualities which education aims to foster through the school subject of mathematics and are a crucial component of the classroom affective environment” (Bishop, et al., 1999, p. 2).

Values have a close affinity with beliefs, but the distinction made by Clarkson, FitzSimons and Seah (1999, p. 3) is that values “are demonstrated in the actions carried out by a person, whereas beliefs can be verbally assented to, but do not necessarily lead to observable behaviour in public”. Values are also closely related to attitudes, with values being held in a deeper and more central position. As with the other dimensions of the affective domain, the vocabulary for values, attitudes and beliefs is often used inter-changeably, again accentuating the complexity of this field (Clarkson & Bishop, 1999).

From their preliminary research into values in mathematics education, the VAMP team have revealed that values tend to be implicit rather than explicit in the classroom (Bishop & Clarkson, 1998). Indeed, many of the teachers they worked with were initially quite surprised at the suggestion that they were teaching values in their mathematics lessons. The researchers commented that

... although values teaching and learning go on inevitably in all mathematics classrooms, most of it appears from our preliminary studies to be done implicitly, and therefore there is only limited understanding of what values are being taught, and of how much mathematics teachers are aware of what values they are encouraging. The intention here is to move teachers' knowledge from implicit to explicit. (Bishop & Clarkson, 1998, p. 7)

Furthermore, they suggested that there are three kinds of values in mathematics teaching: general educational values, mathematical values, and mathematics educational values (Clarkson & Bishop, 1999). Their project focussed primarily on the latter of these three components, which included aspects such as clarity, flexibility, consistency, persistence, creativity and conjecturing (Clarkson, Bishop, FitzSimons & Seah, 2000).

### *Attitudes*

While research into beliefs in mathematics education is relatively new, McLeod (1992) suggested that research into attitudes has a comparatively long history. He commented however, that most of these studies have been quantitative in nature, and there is a need for research into this field that uses multiple research methods including a significant qualitative component. Of the literature found, the major emphasis was on measuring attitudes to mathematics and mathematics education, and the implications of these attitudes on mathematical learning. These quantitative studies have been useful in identifying the issue of poor attitudes to mathematics, but they have not added greatly to our understanding of the underlying reasons for the problem. In addition, there appeared to be limited emphasis on the development of attitudes over time.

As with the other dimensions of the affective domain, there is some confusion in the concepts and views that are labelled attitudinal (Rokeach, 1968). Often terms like anxiety, confidence, motivation, enjoyment, feelings and beliefs are used



when discussing attitudes, which highlights the interconnected nature of the affective domain. Way and Relich (1993, p. 581) commented that, “although definitions of attitude vary, they generally include the idea that attitudes are learnt, manifest themselves in one’s response to the object or situation concerned, and can be evaluated as either being positive or negative.” Taylor (1992, p. 13) developed a broad definition of attitude that saw it as, “a way of thinking, feeling, and acting”, as illustrated in Figure 2.1 below:

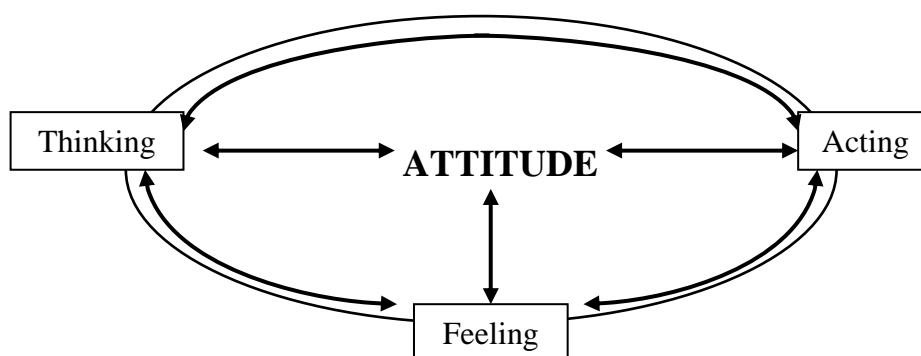


Figure 2.1: Attitude defined (Taylor, 1992, p. 13)

After conducting an extensive review of research into affect in mathematics education, McLeod (1992) defined attitudes as, “affective responses that involve positive or negative feelings of moderate intensity and reasonable stability” (p. 581).

Given the above conceptualisations of attitudes, it would seem logical that attitudes develop from several similar emotive responses to an event or object.

Repeated emotional reactions to mathematical situations become habitual and an attitude towards mathematics develops. This attitude can be characterised as being more stable, less intense, and of which the learner is more aware than a single emotional reaction. (Owens, et al., 1998, p. 109).

McLeod (1992) suggested that attitudes develop in one of two ways, the first being similar to that outlined above. “A second source of attitudes is the assignment of an already existing attitude to a new but related task” (p. 581). Taylor (1992) developed a model that conceptualised the development of mathematical attitudes within a Vygotskian framework. Her model highlighted the environmental,

cultural and social context of attitudes, and she suggested that attitudinal change occurred through “meta-awareness” which involves reflecting on the milieu of one’s feelings, thoughts and actions (p. 15).

The general consensus in the literature is that attitudes do impact and influence behaviour, although the relationship is not well understood (Rokeach, 1968). If attitudes are seen as predispositions to action which invoke preferential responses to the event or object concerned, then indeed they would effect behaviour within contextual parameters (Richardson, 1996).

Unfortunately, it appears that many people have a negative attitude to mathematics, which has been largely formed at school (Carroll, 1994a, 1998b; Hubbard, 2001). In reviewing mathematics education in the United States of America, Braswell, Luthus, Grigg, Santapar, Tay-Lim and Johnson (2001) clearly stated that student attitude to mathematics influenced performance. Anttonen (1969) also found a strong positive correlation between mathematics attitude and mathematical achievement. Furthermore, Ma (1990) found a reciprocal relationship between attitude toward mathematics and achievement in mathematics and in doing so, highlighted a possible self-perpetuating negative (or positive) cycle.

As with beliefs, there is some research support for the idea that teachers’ pedagogical practices and their students’ development are influenced by their teachers’ attitudes to mathematics (Leder, 1992; Relich & Way, 1992; Way & Relich, 1993). Reports have suggested that a majority of primary teachers have negative attitudes to mathematics and this may lead to them possessing a poor self-concept of themselves as mathematics teachers (Kelly & Tomhave, 1985). This led Relich and Way (1992) to comment:

If it is accepted that it is highly desirable for teachers of mathematics to exhibit positive attitudes then the high proportion of preservice teachers found to hold negative attitudes towards mathematics is somewhat alarming. (p. 461)

### *Feelings*

Emotions or feelings are generally described as being temporary and unstable, arising as an affective response to a particular situation. The boundary between attitudes and feelings is unclear to say the least, with attitudes being seen as more permanent and consistent versions of repeated feelings to a particular event or object (McLeod, 1992). Ball (1990, p. 462) commented that, “prospective teachers’ feelings are part of the way they participate in and understand mathematics, not a separate affective dimension called “attitude”, and are a critical area of focus for teacher education.” The importance of this issue was highlighted by her descriptions of some primary teacher candidates as having “intense feelings of dislike, fear, and anxiety” (p. 462).

In their study with preservice primary teachers, Aldridge and Bobis (2001) found that many had emotive responses to mathematics including “panic and blackout”, and some participants expressed feelings of “boredom and frustration” (p. 46). Beswick and Dole (2001) also reported that many preservice teachers had strong emotional responses to mathematics and their feelings often inhibited their development as teachers of mathematics. Amongst the general public, Furner (2000) suggested that two-thirds of Americans either loathe or hate mathematics. To this end, many, at least in Western societies, are said to suffer from *maths anxiety* (Dossel, 1993; Kogelman & Warren, 1978).

*Maths anxiety* is a concept that has received considerable attention from researchers, and regardless of whether it is an emotion or an attitude, it is an issue for primary school teachers (Carroll, 1994a; Kelly & Tomhave, 1985). It can be defined as a fear of learning and using mathematics, and not surprisingly, it is often accompanied by *maths avoidance* and poor achievement in school mathematics (Ball, 1990; Kogelman & Warren, 1978). Dossel (1993, p. 4) suggested that someone suffering from maths anxiety would experience feelings of “panic, helplessness, paralysis and mental disorganisation” when they were faced with a mathematical problem. Carroll (1994a) claimed that many people are inhibited by negative feelings about mathematics education, and a significant number of preservice and inservice teachers exhibit and describe feelings of

anxiety regarding their own learning of mathematics. Mayers (1994) suggested that math anxiety can impact on teaching practice, because teachers who are anxious about mathematics are more likely to adopt beliefs about mathematics education that are instrumental and less focussed on conceptual understanding.

Maths anxiety seems to have considerable implications for preservice primary teachers. Kelly and Tomhave (1985) noted that women are more likely to suffer from math anxiety, but also the largest proportion of primary teachers are women. They suggest from their study that female primary school teachers may indeed be continuing *maths anxiety* with the young girls in their classrooms. In New Zealand the majority of the primary teaching force are women, and so the issue may be relevant. There has been little research done on this issue in the New Zealand context, and therefore, there is scope for significant and necessary inquiry. The thoughts of Buerk (1985) are of interest:

Many [women] ... avoid mathematics – often with strong attitudes and feelings. If indeed one sees mathematics as ‘absolute,’ already all known, and sees mastering it in terms of learning someone else’s products with no sense of their process, then it makes great sense that many reasonable women would choose to avoid it. They are rejecting a view of mathematics that is inconsistent with the principles of the discipline. These women are making an important intellectual statement ... (p. 65)

Once again the complex nature of the affective domain is evident, where many women’s feelings of frustration and powerlessness seem to grow out of a mathematics teaching which tends to be based on an absolutist mathematical epistemology. The recent achievements of girls in secondary school mathematics indicate that the situation may be improving (Garden, 1997).

### *The Affective Domain*

It is difficult to precisely define the affective domain and its components. The various aspects of the affective domain have not been singled out in this project. Rather, they are studied as a complex, inter-related whole as indicated in the diagram below.

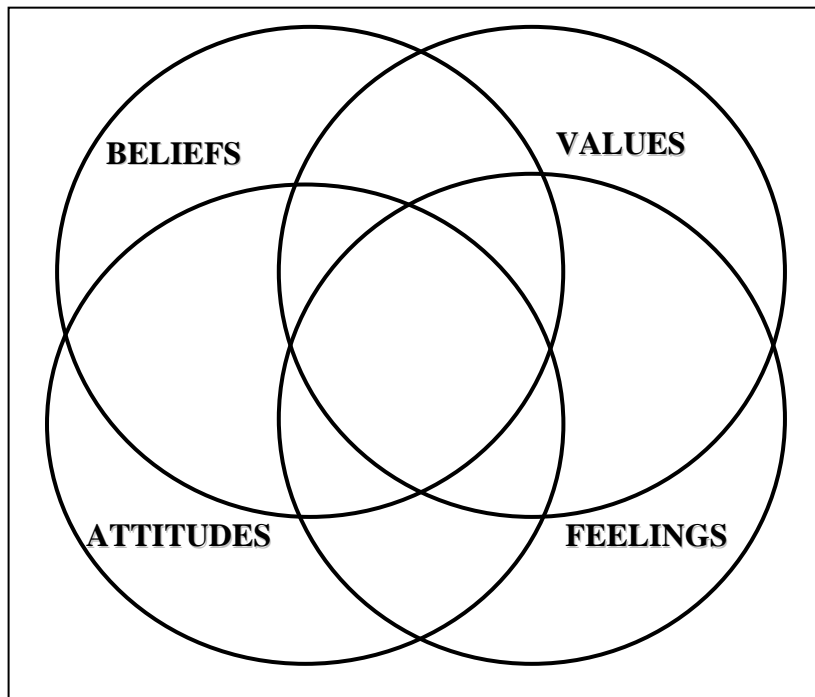


Figure 2.2: The Affective Domain

The affective domain represents the deeply held personal views of individuals and as such, they are often firmly held and jealously guarded. When dealing with peoples' affective qualities one needs to be empathetic, respectful and sincere if understanding and growth is to result (Sowder, 2001).

### **The Impact of Affective Factors on Teachers, Teaching and Teaching Mathematics**

As mentioned above, the relationship between the various affective components is complex, as is the association between the affective domain, cognition and action.

Putman, Heaton, Prawat and Remillard (1992) suggested that there is a

... complex interrelationship between teachers' classroom practice and what they know and believe about mathematics and how it is best taught and learned. ... what teachers know and believe guides how they construct lessons, interpret textbooks, and interact with students. Knowledge and beliefs also provide important lenses and filters through which teachers perceive and act on various messages to change the way they teach. (p. 214)

This section explores some of the ideas around the impact of the affective domain on teachers, teaching and specifically mathematics teaching.

### *The Impact of Affective Factors on Teachers and Teaching*

In reviewing research on the role of attitudes and beliefs in learning to teach, Richardson (1996) suggested that affective factors drive classroom practice and influence the teacher development process. Stipek, et al. (2001) refer to a substantial body of research which suggests that teachers' beliefs and values about teaching and learning affect their teaching practices. In their own research they found that teachers had a consistent set of beliefs that seemed to determine their pedagogical practices, thus supporting the notion that teaching is influenced by affective factors.

Some have suggested that teaching is a practice that is not simply *influenced* by affective factors, but is an affective practice per se (Bishop, et al., 1999; Hargreaves, 1998a, 1998b; Kagan, 1992). Hargreaves (1998a) argued that teaching itself is an emotional practice:

Teaching cannot be reduced to technical competence or clinical standards. It involves significant emotional understanding and emotional labour as well. ... It is time for educational change strategies and reform efforts, and for definitions of teaching and learning standards to come to terms with and embrace these emotional dimensions of teaching and learning – for without attention to emotions, educational reform efforts may ignore and even damage some of the most fundamental aspects of what teachers do. (Hargreaves, 1998b, p. 850)

Bishop (2000) argued that all teachers were teachers of values, and that values education was a fundamental aspect of teachers' practice whether they were aware of it or not. Indeed, the process of learning to teach and the practice of teaching are affective at their core:

... the practice of classroom teaching remains forever rooted in personality and experience and that learning to teach requires a journey into the deeper recesses of one's self-awareness, where failures, fears, and hopes are hidden. (Kagan, 1992, pp. 163-164)

While it seems fairly clear that affective factors do influence teaching practice, the relationship is not necessarily a simple or direct one (Macnab & Payne, 2000). In terms of preservice teachers, Tillema (2000) found that the relationship between their beliefs and performance was small, and that, "although student teachers' beliefs do exist at the time of practice teaching, they do not seem to exert much

influence upon, or interfere with, their learning ... during the practice-teaching period” (p. 586). This highlights the contextual influences on beliefs and practice, which are but one of the many factors that add to the complexity of the teaching endeavour. The role and influence of knowledge on practice and affective position is unclear and complex, and indeed the distinction between knowledge and belief is ill-defined (Barkatsas & Chionidou, 2001; Richardson, 1996). Moreover, it seems that the relationship between affective factors and practice is interactive in that beliefs and values can drive action, but experience and reflection upon action can lead to affective change (Richardson, 1996).

Worldwide, policy documents and curriculum statements for mathematics education promote an affective dimension as an integral part of mathematics learning (Schuck, 1997b). However, it appears as if this affective perspective, or the impact of teachers’ affective dispositions, has not been widely considered in the practice of mathematics education.

#### *The Impact of Affective Factors in Teaching Mathematics.*

There is significant support in the current literature for the view that teachers’ beliefs, values, attitudes and feelings influence their mathematics teaching practice (Aldridge & Bobis, 2001; Andrews, 2000; Haggarty, 1995; Handel, Bobis & Grimison, 2001; Hobden, 2001; Keast, 2001; Nisbet & Warren, 2001; Putman, et al., 1992; Sparrow & Frid, 2001; Stipek, et al., 2001). The impact is primarily tacit and unintentional, but it is fundamental through all aspects of mathematics teaching from planning and preparing to the classroom environment and instructional practice (Artzt, 1999).

In considering the decision-making of mathematics teachers’, Archer (1999) suggested that beliefs were the most significant factor that influenced their instructional practices. Nesbitt Vacc and Bright (1999, p. 91) stated that, “teachers’ beliefs about teaching and learning mathematics significantly affect the form and type of instruction they deliver”. Others also concur with the premise that there is a connection between what teachers believe about mathematics and mathematics teaching and learning and their actual practice of teaching

mathematics (Artzt, 1999; Cooney, et al., 1998; Mayers, 1994; Thompson, 1992). Mayers (1994) outlined some ways that teachers' beliefs might impact on their practice of teaching mathematics, including their choice and use of instructional techniques. She suggested that teachers most commonly held a traditional view of mathematics, which tended "to lead to a 'transmission' model of teaching characterised by exposition, practice, and learning, known as instrumental teaching" (p. 420). Others noted that teachers who had a rigid view of mathematics often used the "teaching by telling" approach, and those who were anxious or lacking in confidence would employ an instrumental pedagogy (Carroll, 1998a, 1998b; Nisbet & Warren, 2000; Prawat, 1992; Putman, et al., 1992). These instructional practices influenced students' perceptions of mathematics, which in turn impacted on the students' learning and achievement. Similarly, it is argued that teachers' attitudes also impact their teaching of mathematics and their students' learning in mathematics classes. Relich and Way (1992) suggested that while the research evidence is inconclusive, "it has been sufficient to suggest that positive teacher attitudes contribute to the formation of positive pupil attitudes" (p. 460). Perhaps it was for these reasons that Bromme and Brophy (1986) were moved to comment:

It is important that [preservice teachers] learn to view mathematics positively. For one thing, teachers regularly model their own attitudes and beliefs in the process of teaching their pupils. Much of this occurs without the teacher's awareness, but it communicates information to the pupils nevertheless. Therefore, pupils of teachers who view mathematics as interesting, enjoyable, and useful are likely to develop much more positive attitudes towards the subject than pupils of teachers who see mathematics as dull, difficult or likely to be rewarding only for certain people who possess (genetically based) special aptitudes for it. (p. 76)

Furthermore, Carroll (1998b) suggested that there was some evidence to support the notion that teachers' feelings and attitudes about mathematics can influence student achievement in the subject.

Since the Third International Mathematics and Science Study (TIMSS) in 1996, there has been some concern about teachers' attitudes and confidence to mathematics in New Zealand. In reviewing New Zealand's performance in the TIMSS, Garden (1997) regarded the teacher as the greatest influence on students' achievement. The review identified poor attitude to mathematics as a significant teacher factor in student underachievement and they recommended that support



was needed to improve teacher confidence in mathematics. This was followed up by government sponsored projects in numeracy that amongst other things, sought to improve teacher's confidence in mathematics (Ministry of Education, 2001).

The significance of teacher attitudes, beliefs and values about mathematics teaching is often revealed when people are asked about their school mathematics experience. "Many people seem to be constrained by negative attitudes, beliefs and feelings about mathematics and mathematics learning" (Carroll, 1994a, p. 131). In her research with preservice primary teachers, Schuck (1996) found that many entered their teacher education programme with a negative attitude towards mathematics, and their attitude was a "chain that bound them" as they developed in their teaching career. The affective cycle outlined previously is indeed a product of the continuing impact of affective factors in mathematics education. Davis (1999) expressed his view of the dilemma:

Personally I am convinced that there is little hope or substantive change in the culture of school mathematics without deepened appreciations of enacted beliefs on the nature of the discipline – and, of course, of the rationales for teaching the subject matter that fall out of those beliefs. (p. 26)

## **Experiences of Mathematics and Mathematics Education**

It is clear that there seems to be a relationship between a person's experiences of mathematics and mathematics education, and their corresponding affective dispositions. Klein (2001) noted that preservice primary teachers begin their teacher education programmes with "visceral, emotional, often unconscious experiences of learning mathematics that constitute their *knowing* about mathematics and themselves as mathematically able or not" (p. 339, italics in the original).

Preservice primary teachers have usually experienced mathematics in three broad spheres: (1) in everyday life; (2) as a school student themselves; and (3) as a tertiary student in their teacher education programme. The third of these spheres – as a tertiary student, can be further delineated into two further realms, namely mathematics education courses and practicum.

### *Experiences in Everyday Life*

Perhaps the most significant feature of the literature related to experiences of mathematics education is the absence of attention to experiences outside formal education, although this oversight has been addressed to some extent in recent years (Carter & Knight, 1994; National Council of Teachers of Mathematics, 2000). A possible explanation could be the recognition of mathematics as only a school subject that is unrelated to life outside the classroom. There appears to be a dualistic view of mathematics where *school mathematics* and *used mathematics* are seen as somewhat independent, and people may not recognise that they are using mathematics daily.

### *Experiences as a School Student*

Schuck (1998, p. 704) suggested that “prospective teachers constantly evaluate pedagogical ideas in terms of their own anticipated reaction to the ideas, had they been students”. She proposed that in preservice teacher education the “self-as-teacher” was invented based on the experiences of the “self-as-student”, therefore giving great significance to their school experiences of mathematics. The crucial role of school mathematics experience has also been noted by a number of other researchers (Biddulph, 1992; Bobis & Cusworth, 1994; Carroll, 1994a; Cooney, et al., 1998; Davies & Savell, 2000; Grootenboer, 2000; Gunstone & Northfield, 1994; Joram & Gabriele, 1998; Mayers, 1994; Nesbitt Vacc & Bright, 1999), and was highlighted by Kagan (1992):

Candidates come to programs of teacher education with personal beliefs about classrooms and pupils and images of themselves as teachers. For the most part, these prior beliefs and images are associated with a candidate’s biography: his or her experiences in classrooms, relationships with teachers and other authority figures, recollections of how it felt to be a pupil in classrooms. ... Candidates often extrapolate from their own experiences as learners, assuming that the pupils they will teach will possess aptitudes, problems, and learning styles similar to their own. (p. 154)

School experiences of mathematics were seen as important in the development of teachers’ affective views towards mathematics (Carroll, 1998b). It seems as if the impact of these school experiences can endure well into adult life as people hold

onto the beliefs, attitudes and feelings they have about mathematics (Beswick & Dole, 2001; Bishop, FitzSimons, Seah & Clarkson, 2001; Klein, 2001). In particular, Kogelman and Warren (1978) suggested that feelings of anxiety about mathematics developed at secondary school when many perceive that mathematics becomes difficult and abstract.

The pervasive influence of school experience on the developing teacher is a concern for mathematics educators when the nature and tone of their personal biographies have been often negative and disabling. In the New Zealand context, Biddulph (1992, p. 128) found that a majority of preservice primary teachers were negatively disposed towards mathematics “mostly because of negative experiences in the subject while at school”. His later research reported that by the end of their primary schooling (age 12), only 25% of students remained positive about mathematics, and their secondary school mathematics experiences were similarly poor. He concluded that their resulting negative feelings tended “to be deeply ingrained” and difficult to overcome (Biddulph, 1999, p. 68). Other New Zealand (Davies & Savell, 2000; Mayers, 1994), Australian (Bobis & Cusworth, 1994, 1997; Carroll, 1994a; Relich & Way, 1992; Schuck, 1996, 1997b; 1998, 1999) and international researchers (Ball, 1990; Buerk, 1985; Cooney, et al., 1998; Nesbitt Vacc & Bright, 1999) present a common theme of negativity when reporting on the school experiences of preservice primary teachers:

Perhaps the strongest chain binding the [primary teacher] students is the chain of past experience in mathematics. Many of the students perceived mathematics as being dualistic in nature, and as being boring, tedious and difficult. They speak of their past experiences without enthusiasm, but are quite accepting of the fact that this is how mathematics has to be. (Schuck, 1996, p. 126)

In outlining negative experiences of school mathematics, the role and personality of the teacher was often mentioned, with many being able to remember in great detail the attributes of certain teachers (Carroll, 1994a; Ernest, 1988; Grootenboer, 2000; Gunstone & Northfield, 1994; Joram & Gabriele, 1998; Kogelman & Warren, 1978; Picker & Berry, 2000). Indeed, it also appears to be that those who espouse a positive view of mathematics also refer to their teacher’s personality, enthusiasm and teaching competence. In either case, it is interesting that one

influence - the teacher - which at least superficially has little to do with mathematics, is so significant. Other factors that were not particularly mathematical included lack of understanding and poor performance on tests (Buerk, 1985; Carroll, 1994a, 1994b). In regards to the nature of mathematics, the school experiences appear to be “rule-bound and thin” (Ball, 1990, p. 449), characterised by “quick answers, following rules and knowing and applying the correct rules” (Grouws & Schultz, 1996, p. 447), rigid and formal (Kogelman & Warren, 1978), instrumental (Archer, 1999; Mayers, 1994), irrelevant (Davies & Savell, 2000) and characterised by “teaching as telling” (Joram & Gabriele, 1998, p. 179). In particular, these views seem to merge from secondary school experiences of mathematics which are viewed as abstract and difficult (Hubbard, 2001).

As alluded to earlier, the affective views developed through school experience are a powerful influence in the preservice education of primary teachers, often to the detriment of their professional growth:

...teachers’ beliefs about mathematics and how to teach mathematics are influenced in significant ways by their experiences with mathematics and schooling long before they enter the formal world of mathematics education. Further, these beliefs seldom change dramatically without significant intervention. (Cooney, et al., 1998, p. 306)

Richardson (1996) concurred that the beliefs, attitudes, values and feelings developed through the apprenticeship of observation students undergo at school significantly impacted their teacher education.

#### *Experiences in Teacher Education.*

The experiences of preservice primary teachers are complexly nestled in the beliefs, values, attitudes and feelings they developed as a school student (Virta, 2000). Subsequently, during their tertiary education, preservice teachers experience mathematics and mathematics education in two different contexts, namely in course work and on practicum.

The beliefs, values, attitudes and feelings of preservice primary teachers towards mathematics and mathematics education seem firmly entrenched as a result of their school experiences (Tillema, 2000). In this respect, teacher education is

different from the education of other professions as noted by Trotman and Kerr (2001):

Law and engineering students, for example, do not have the cumulative institutional experience that 12 years of schooling gives student teachers! The personal biography of the student teacher acts as a filter through which they screen any academic and theoretical course content, rejecting that which does not resonate with the observational apprenticeship. (p. 159)

Trotman and Kerr have highlighted that affective positions are difficult to change, but they also act as a filter and a lens for any new ideas presented as part of their tertiary teacher education (Gondoseputro, 1999; Joram & Gabriele, 1998; Kagan, 1992). The relationship then, between affective views and teacher education is a problematic one, where previously held beliefs and attitudes impinge upon teacher education, but teacher education has little apparent effect on affective positions (Raths, 2001; Richardson, 1997; Stipek, et al., 2001).

A number of researchers have found that significant change in attitudes and beliefs are unlikely during teacher education (Artzt, 1999; Bobis & Cusworth, 1997; Cooney, et al., 1998; Gustafson & Rowell, 1995; Kagan, 1992; Nesbitt Vacc & Bright, 1999; Sparrow & Frid, 2001). Nevertheless, many suggested that mathematics educators should address affective issues during the preservice education of primary teachers (Beswick & Dole, 2001; Bobis & Cusworth, 1994; Relich & Way, 1992). Mayers (1994) suggested it was essential that tertiary courses in mathematics education address and induce changes in preservice teachers' beliefs about mathematics and mathematics teaching. Likewise, after reviewing the research on preservice teachers' mathematical beliefs and attitudes, Grouws and Shultz (1996) stated:

Unless teacher educators realise that making an impact on prospective teachers [beliefs and attitudes] requires powerful interventions, it is unlikely that teacher educators will be able to alter the continuity of traditional mathematics teaching and learning. (p. 449)

Clearly, this is not an easy task given the extensive and repeated experiences that prospective teachers had at school, and the limited time frame for (perhaps) experiencing mathematics in a different way during their tertiary programme. Teacher education courses offer a unique opportunity between the preservice teacher's school experience and future teaching practice to pause and reconsider

their affective dispositions towards mathematics teaching and learning. The need for tertiary teacher programmes to have a positive influence on affective qualities is obvious. However, there is limited evidence to suggest how this might be achieved.

Some researchers have reported changes in preservice teachers' beliefs and attitudes towards mathematics during their experiences of mathematics education as part of their tertiary programme. Often these changes were considered small or insignificant (Biddulph, 1999; Owens, et al., 1998). However, Mayers (1994, p. 426) concluded that a constructivist framework for learning in preservice mathematics education courses will enable the development of "positive attitudes towards mathematics and mathematics teaching". She reported that a constructivist framework was instrumental in the successful reform of her participants' mathematical beliefs and attitudes. Jones, Brown, Hanley & McNamara (2000) explored the transition from "learner of mathematics" to "teacher of mathematics" with preservice teachers in their cross-sectional study. They depicted the participants' journey:

First, mathematics as a demon is powerful and in various ways it subjugates the student and fills them with fear and loathing. But, in jumping out of the closet, mathematics is 'outed'. It is removed from the dark and abstract underworld. In the light it is possible to see mathematics' softer side. This aspect, besides being fun, is also basic and practical. In fact, maths is so friendly that, besides letting it loose with children, you can, if you are so inclined, let it lick you. (p. 9)

Indeed, their findings indicate that it is possible to see change in the affective responses of preservice teachers towards mathematics.

Gunstone and Northfield (1994) and Beswick and Dole (2001) suggested that a significant factor in preservice teachers' attitudinal development was the lecturing staff, in much the same way that secondary teachers have influenced them as school students. Therefore, tertiary experiences of mathematics and mathematics education need to encourage positive attitudes, values and beliefs. Further to this, the tertiary experience needs to include explicit opportunities for preservice teachers to consider and reflect upon their beliefs so they can be purposely reviewed (Nespor, 1987; Schuck, 1997a; Tillema, 2000). Other strategies reported

to be successful in reforming the beliefs and attitudes of preservice teachers included:

- engaging them in doing mathematics;
- collaborative group work;
- uncovering and reflecting upon prior beliefs and attitudes;
- providing and modelling different mathematical pedagogies; and
- critical reviewing of practicum experiences (Beswick & Dole, 2001).

A significant aspect of teacher education programmes is the school experience often referred to as teaching practice, practicum, or student teaching. It has the power of experience to critically shape the student teacher's perceptions of teaching and learning (Gustafson & Rowell, 1995). Clearly, practice in schools is an important aspect of learning to teach, but it can become an unintentional apprenticeship of uncritical, miseducative practice (Calderhead, 1988). Samaras and Gismondi (1998) noted that "the practicum has been viewed as an unmediated and unstructured apprenticeship which lacks course work and adequate supervision" (p. 716). Practicums provide experiences that cannot be replicated in the tertiary classroom, but unless structures are in place to promote reflection and evaluation, the practicum can become an experience of uncritical practice.

As students of the craft of teaching, preservice teachers are observing and participating in the practices and rituals of teachers in the field as they participate in the authentic activity of teaching. They become involved in the wider aspects of the teaching community through meetings and staffroom discussions, appropriating the required dress codes, norms of behaviour, beliefs, values and attitudes of those in the profession. As such, they are appropriating the existing culture of the teachers in that particular school (Kagan, 1992):

... the newcomers legitimate peripherality provides them with more than an observational lookout post: It crucially involves participation as a way of learning - of both absorbing and being absorbed in - the culture of practice ... with opportunities to make the culture [of teaching] theirs. It is our belief that neophytes' knowing about teaching develops not only through membership in a community, but through their interest in becoming agents of its activity. (Samaras & Gismondi, 1998, p. 720)

Archer (1999) suggested that novice mathematics teachers tended to adopt and/or assimilate the beliefs and practices of senior colleagues. As such, the practicum is often a major influence on the affective development of preservice teachers (Gustafson & Rowell, 1995). In an overview of the professional growth of preservice teachers, Kagan (1992) was critical of the idiosyncratic and unstructured nature of the school experience. Kagan (1992), Mewborn (1999) and Nesbitt Vacc and Bright (1999) all promoted the need for preservice teachers to reflect critically upon their school experiences and in particular, the beliefs and values of both themselves and their associates in the school setting. Often the practicum experiences are similar to their own school experiences, thus reinforcing the beliefs and practices they developed as school students. In this regard they see the practicum as a real experience of mathematics teaching and learning and can discount the tertiary course-work experiences (Richardson, 1996). As opposed to the usual practicum experiences outlined above, Hill (2000a) suggested that preservice teachers need plenty of meaningful teaching-practice if they are to be encouraged to relinquish their familiar beliefs and attitudes in favour of new views and dispositions of mathematics teaching and learning:

For meaningful and lasting change in attitudes and practices to occur in mathematics education, students must practice teaching mathematics for relational understanding, experience the responses of children to their teaching approaches, and discuss and reflect on these experiences. The cycle must be repeated over a substantial period, allowing time for students to become familiar with the new ideas. (p. 29)

This seems particularly important in the teaching of mathematics given the perpetual negative cycle of beliefs and values towards mathematics (Ball, 1990). These authors all suggest that through this reflective process, preservice teachers can become aware of their own beliefs, values, attitudes and feelings, and therefore, be more deliberate in their affective growth.

## **Theoretical Framework**

The theoretical framework for this study was grounded in constructivist principles. Constructivism is not a clearly defined single theory, but rather it has many forms (Geelan, 1997). Furthermore, there are other learning theories that are



consistent with and complementary to constructivism, including ‘situated cognition’ (Lave & Wenger, 1991) and ‘learning from experience’ (Boud, 1993) both of which were also used as a theoretical base for aspects of the present project. In this section constructivism and learning from experience are briefly explored, and some emerging themes are identified, particularly as they relate to the development of beliefs, values, attitudes and feelings.

### *Constructivism*

Geelan (1997) identified at least six varieties of constructivism and he suggested that he had not exhausted the field. Two of the main schools of thought within constructivism are *radical constructivism* as promoted by von Glasersfeld (1989), and *social constructionism* developed from the work of Vygotsky (Wertsh & Toma, 1992).

Radical constructivism is founded on two basic principles:

- (1) knowledge is not passively received but actively built up by the cognising subject;
- (2) the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality (von Glasersfeld, 1989, p. 162).

The individual alone constructs their knowledge as they seek to make sense of their experiential world. Thinking within an individual cannot be instructed by external reality, the world outside the person can only act negatively to problematise existing constructions (von Glasersfeld, 1996). Radical constructivism is a metaphor for learning which is ontologically neutral and epistemologically fallibilistic (Ernest, 1994). Within this metaphor, there is no concept of *absolute truth*, for we have no way of knowing if such a thing exists. What then is significant, is the idea of *viability*. If a particular experience is repeated it reinforces the mental *constructs* or *schema* in the person’s mind, thus making it a viable construct (Piaget, 1967). These schema or “mental maps” (Begg, 1995) are not permanent fixtures, as they can be adapted when a *perturbation* occurs, through experience. The cognising subject can *accommodate* the new experience by modifying existing schema, or reject the perturbation, and

therefore re-establish equilibrium (Konold & Johnson, 1991; Romberg, 1988; von Glasersfeld 1995; Wheatley, 1991).

Social constructionism stands apart from radical constructivism, in that the radical constructivist model does not emphasise the significance of social interaction in learning. The social constructionists “tend to take society as a given” (von Glasersfeld, 1993, p. 24), but the radical constructivist would not perceive society in such a way. The socio-cultural perspective views knowledge as residing within the society, and an individual’s cognition is always embedded within a cultural context. Vygotsky had a major influence in the development of social constructionism, picturing learning as a process of enculturation rather than individual, idiosyncratic construction. While not denying individual construction, he saw it as secondary to, and as a derivative of the *social dimension of consciousness* (Wertsh & Toma, 1992):

The Vygotskian project (is) to find the manner in which aspirant members of a culture learn from their tutors, the vicars of their culture, how to understand the world. That world is a symbolic world in the sense that it consists of conceptually organised, rule bound belief systems about what exists, and about how to get to goals, about what is to be valued. There is no way, none, in which a human being could possibly master that world without the aid and assistance of others for, in fact, that world is others. (Bruner, 1994, p. 32)

Within the social constructionist view, the individual’s cognition in internalising the knowledge is where the construction occurs (Rogoff, 1990). The cognising subject reconstructs and individually reorganises the experiences they have met within the community (Driver & Scott, 1995). Wheatley (1991) accounts for social factors by suggesting that “individuals co-construct knowledge”.

Between the radical constructivist and social constructionist there are distinct differences, but they also share a great deal in common (Ernest, 1994), and what is important is not whether individual cognition or social enculturation is primary, but how the two perspectives can be combined (Simon, 1995). Bereiter (1994, p. 21) suggested that there was “nothing incompatible” between the two views and that “neither one implies rejection of the other”. Cobb (1994) promoted the need for both perspectives, particularly in his work in mathematics education, suggesting that, “Each of the two perspectives, the sociocultural [social

constructionist] and the [radical] constructivist, tells half of a good story, and each can be used to complement the other” (p. 17). His work began using the radical constructivist model as he studied learning in mathematics classrooms, but he was influenced by the work of Vygotsky as he perceived the inadequacies of his metaphor in understanding the social nature of learning (Howe, 1996). According to Cobb (1994), learning is both a process of socialisation into a greater community of practice and a process of active personal construction. This pragmatic approach taken by Cobb can account for the dual nature of learning by focusing on a particular perspective when it is appropriate. In this respect, he views the radical constructivist and the social constructionist metaphors as complementary, each “constituting the background for the other” (Cobb, 1994, p. 19).

Hung (1996, p. 356), in commenting on constructivism in general stated:

Knowledge [in constructivism] is not something that can be obtained through the mind alone. Nor is it something that belongs to the preserves of the senses. It is not even something that can be arrived at through the cooperation of the mind and the senses, each faculty doing part of the task, as factory workers would at a conveyer belt. Rather ... the mind and the senses are not two distinct faculties working in cooperation. They are so inextricably entwined in their operations that it would be wrong to describe them as separate parts. The correct picture is that knowledge is the end product of a constructive-cum-collecting process by a unified cognitive faculty composed of the mind and the senses.

### *Situated Cognition*

The concept of situated cognition promoted by Lave and Wenger (1991) is sympathetic to constructivist notions of learning. After considering the learning of apprentices in their chosen trades, Lave and Wenger (1991) suggested that learning was a central part of social practice, and situated cognition was a useful analytical tool for understanding learning. A prime tenet of their view of learning was the concept of ‘legitimate peripheral participation’ which highlighted “the process by which newcomers become part of a community of practice” (Lave & Wenger, 1991, p. 29). This process was characterised by asymmetrical participation by learners and masters in legitimate activities as the neophytes progress toward complete participation in the “sociocultural practices of the community” (p. 29). In that sense, the relationship between the master and student

is to confer legitimacy rather than to provide teaching (Brown, McNamara, Hanley & Jones, 1999). Legitimate peripheral participation places learning as an integral part of life as the individual engages with the social community in which they live, work and learn. Learning is always situated within a context, and that context is an indivisible aspect of that learning. Lave and Wenger (1991, p. 29) emphasised the integrated nature of learning and community participation;

In situated cognition, learning is seen as a process of enculturation, and conceptual knowledge as contextual, referenced to the world in which the knowledge is being produced. Knowledge therefore, would not be considered infallible but rather, as incomplete, as it is always under construction as the context it is learned and used in changes (Hennessy, 1993). To this end, learning is also grounded in experience as the learner engages in the authentic practices of the community.

#### *Learning from Experience*

Although learning occurs in many different ways, and in a variety of situations, cultures, communities and contexts, Boud (1993) suggested that there are certain fundamentals:

- Experience is the foundation of and stimulus for learning.
- The effects of prior experience influence all learning.
- Learners actively construct their own experience.
- Learning is a holistic process which has affective, cognitive and conative features.
- Learning is socially and culturally constructed.
- Learning occurs in a socio-emotional context. (pp. 35-36)

The concept of *learning from experience* places the experience of the learner as the prime guiding influence in learning. Experience is more than just a starting point for further education, it is the central mediating aspect of a learner's development. This means of course, that in any particular learning community (e.g. a class), there will be a wide range of experiences represented amongst the learners, and probably the older the group, the broader the range of experiences. Experience also encompasses feelings, emotions and values as they are an integral

part of life. Learning needs to consider these affective factors so students will be able to use their knowledge to function effectively in modern society.

Learning from experience places a high emphasis on the context of learning.

We must also engage the actual experience of learners so that they can make connections and identify relationships between what they already know and what they are learning anew. ... This typically will involve putting information in context, making initial access very concrete, portraying knowledge in a human context as part of the understanding needed to deal with real situations rather than abstracted ones, and making access to different forms and modes of expression of the ideas (Boud, 1993, p. 37).

The contextualization of education makes the learning more meaningful, connected, and multi-layered, allowing learners to see a human element in their study. Students are therefore less likely to feel alienated from the knowledge they are learning as they can connect on an affective and conative level, as well as cognitively (Boud, 1993).

In Figure 2.3, the threads of the *learning from experience* model are represented diagrammatically. The *personal foundation of experience* of the learner is made up of all their previous learning experiences, including the affective factors they may have developed. It is likely that learners will be only partly aware of their personal foundation, and much of it will remain tacit. *Intent* involves the learner's purposes for engaging in the learning experience.

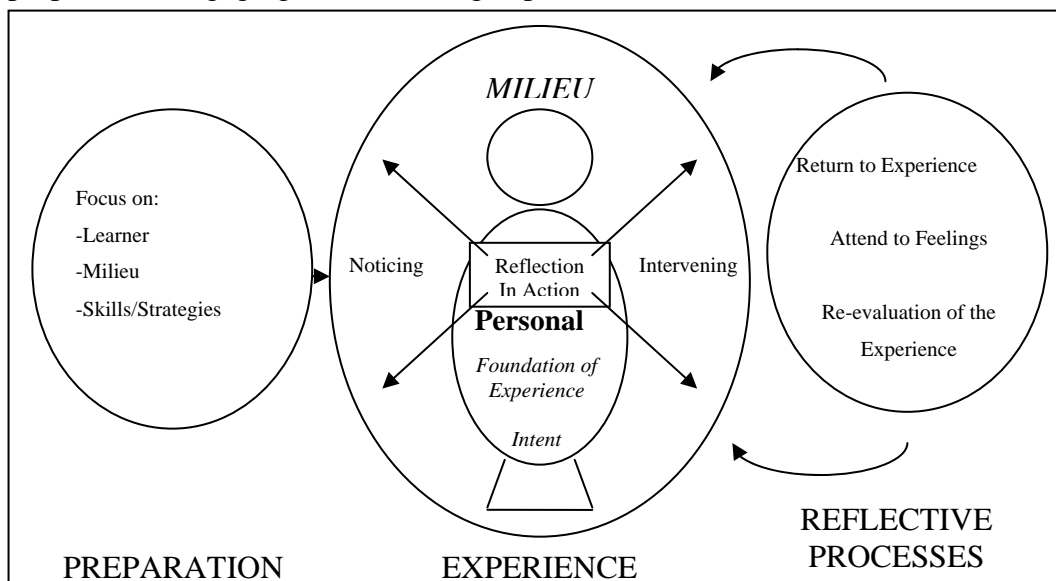


Figure 2.3: A model of Learning from Experience (Boud & Walker, 1991, p. 68)

Mason (1993, p. 113) refined the model of learning from experience to “intentional learning from experience”. He commented; “One thing that people do not learn from experience, is that they do not often learn from experience alone”.

The key process in learning from experience is *reflection* (Boud, Keogh & Walker, 1985; Mason, 1993). In the model illustrated previously (Figure 2.3), the reflective processes are represented in the right-hand circle. Mason (1993, p. 117) outlined the central function of reflection:

This process, this cycle of activity, reflecting on recent experience, relating it first to the past and then to the future, and then validating that against the experience of others, is, I suggest, the essence of how people actually do learn from experience.

Reflection is the key mediating function between experience and learning, and it is the process that makes learning intentional from experience. As such it has an integral place in understanding how people learn and develop.

## **Summary**

Aspects of the literature have highlighted the significant influence of affective factors in the development of preservice primary teachers in mathematics education. Clearly, the affective domain is a complex phenomenon with a number of inter-related facets. Key aspects of the affective domain in the present study include beliefs, values, attitudes and feelings. A number of writers suggested that beliefs and attitudes develop from prior experience, and these views can significantly impact primary teachers’ mathematical teaching practice. Unfortunately, a number also comment that many primary teachers have had negative experiences of mathematics, and this has ramifications for the teaching of mathematics in primary schools. Some researchers found that tertiary programmes can impact preservice primary teachers’ affective dispositions towards mathematics, although the magnitude of the improvements was small. Throughout the literature there was an underlying message that the negative affective views of primary teachers needs to be addressed if mathematics learning is to improve. It is this issue that is explored and extended in this thesis.

## **Chapter 3: Methodology and Method**

This chapter outlines the methodology that underpins the present study and then proceeds to elaborate on the actual methods and procedures used to conduct the research. First, the research questions are outlined. Then, the methodological considerations of the study are discussed, with particular reference to the phenomenological theoretical framework. Finally, a description and justification is given for the methods used in the study, including an outline of the actual procedures employed.

### **Research Questions**

The concerns expressed in the introductory chapter together with the problems raised as a result of the literature review gave rise to the following research questions which guided the present study.

#### *Main Question*

How does experience influence the beliefs, values, feelings and attitudes of preservice primary school teachers towards mathematics?

#### *Sub Questions*

1. How have preservice primary school teachers experienced mathematics at school?
2. What beliefs, values, attitudes and feelings do preservice primary school teachers have towards mathematics and the teaching and learning of mathematics?
3. What influences their beliefs, values, attitudes and feelings towards mathematics and what are the implications for teacher education?
4. How do the beliefs, values, attitudes and feelings of preservice primary school teachers change over time?

## **Methodology**

The focus of the present study is the participants' experiences of mathematics and the affective development associated with those experiences. In essence, it is an exploration of their personal interface with mathematics, and their perceptions of those experiences. This personal interface is complex in terms of its characteristics and the challenges it poses for researchers in this area.

A complex phenomenon is characterised by an intricate web of mutually specifying relationships that make the whole greater than the sum of the parts (Waldrop, 1992). Therefore, to study a complex phenomenon meaningfully, it is fitting to use a holistic approach (Maykut & Morehouse, 1994). This desire for a holistic, human methodology led to the predominantly qualitative nature of the study, and the emphasis on experience and perception meant a phenomenological framework was most appropriate (Cohen, Manion & Morrison, 2000). To support the phenomenological approach to the project, some ethnographic techniques were utilised for data collection. In addition, some quantitative analysis was done to monitor changes in the participants' views towards mathematics throughout the study.

### *Phenomenology*

Phenomenology is a research methodology that is qualitative in nature and focuses inquiry on human experience (Polkinghorne, 1989). Experience is that which appears in the synapse between human existence and the world. It is the realm at the intersection of consciousness and external reality (Moustakas, 1994). By emphasising experience as the object of inquiry, phenomenology incorporates sense impressions, perception, imagination, feelings, beliefs and values as being significant, and research undertaken from a phenomenological perspective is descriptive, capturing the experiences of the participants. "Put simply and directly, phenomenological inquiry focuses on the question: 'What is the structure and essence of experience of this phenomenon for these people?'" (Patton, 1990, p. 69).



The descriptive nature of phenomenological research means it is concerned with *seeing* rather than *thinking or explaining* (Kvale, 1996). It is about describing the phenomenon as it is experienced by the participants, without trying to rationalise or justify it. To describe the topic of concern effectively the researcher needs to look at it from many different perspectives, and be open to all descriptions of people's perspectives. A phenomenon can be experienced in an infinite number of ways, and so the task of the phenomenologist is to explore many experiences of the phenomenon so they can determine its essential qualities or essences (Moustakas, 1994).

### *Ontology and Epistemology*

In phenomenology, there is an acceptance of an external reality (Bogdan & Biklen, 1992; Merleau-Ponty, 1962; Moustakas, 1994). However, the *real world* is not the focus of inquiry as phenomenology is concerned with people's perceptions of reality. It is the experience of reality and real objects that are the locus of research, not reality or the objects themselves (Polkinghorne, 1989). The phenomenologist suspends ontological judgements to comprehend more fully the forms that people treat as real (Houlstein & Gubrium, 1994). Patton (1990, p. 57) stated that, "The phenomenologist is committed to understanding social phenomena from the actor's own perspective. He or she examines how the world is experienced. The important reality is what people perceive it to be".

A dualistic ontology is dismissed in phenomenology by accepting that there is a real world, but it is interpreted in various ways, meaning that reality is both subjective and objective simultaneously (Neuman, 1998). It is argued that an objective reality does exist, but an individual can only know what they experience, and therefore, the experiences and perceptions of the individual constitute a significant aspect of reality (von Glasersfeld, 1996).

It is also significant that we do not experience the world as a distant observer, but rather we are an integral part of the world, and our experiences of the world are from the inside (Matthews, 1996). What constitutes our understanding of the real

world is therefore, our experiences and perceptions as we share our *life-worlds* (Hitchcock & Hughes, 1995):

The fact that our being is 'being in the world' must be taken seriously: we are neither disembodied consciousnesses, loosely attached to matter via our own bodies, nor mere physical objects like any other, but human beings who are embodied, who move around the world and have purposes in the world. (Matthews, 1996, pp. 101-102)

Consistent with phenomenological ontology, the epistemology of phenomenology is based on the experiences of the knower (Marton, 1988). Its epistemological foundations are attuned to the special character of human experience, meaning that knowing cannot be separated from being (Polkinghorne, 1989; Smythe, 1997). Foundational phenomenological philosophers, such as Husserl and Merleau-Ponty, suggested that we can only know what we perceive or experience, and therefore, our knowledge is in a sense fallible (Merleau-Ponty, 1962; Patton, 1990). If this is valid then we can only know what we experience, our perceptions and sense impressions are perhaps the only things that we can rely upon, because they are primary forms of knowledge:

... anything that is within us as knowledge such as joy, excitement, or sorrow, actually exists and is unquestionable evidence, in contrast to external things, such as colours, odours, and sounds that exist only in a phenomenal sense. (Moustakas, 1994, p.44)

Furthermore, we are not merely passive recipients of experience, but rather we actively select and construct our experiences and we are complexly and symbiotically involved with our experiences as they unfold.

### *Characteristics of Phenomenological Research*

Phenomenological inquiry uses language and discourse as its main form of data and therefore, it is usually qualitative in nature (Polkinghorne, 1989). It is also interpretive, and reflective, but its main characteristics are:

- It is descriptive;
- It is about meaning-making; and
- It is experientially based

The descriptive nature of phenomenological inquiry is evidenced in all facets of the methodology, and indeed the ultimate purpose of phenomenology is to

produce a description of the phenomenon under investigation (Polkinghorne, 1989). When a phenomenological research project is complete, the result is a clear, rich, thick description of the essential qualities of the particular experience (Bogdan & Biklen, 1992). Smythe (1997, p. 16) suggested that phenomenological descriptions should be *poetic* as the researcher was involved with “finding the best words, put together the best way to capture the experience in its full richness and depth”. The descriptions will also be *textual* including “thoughts, feelings, examples, ideas, [and] situations that portray what comprises an experience” (Moustakas, 1994, p. 47). To be able to do this the phenomenologist’s data are first-person descriptions of the experience. The researcher needs as much as possible, to put aside all personal preconceptions of the phenomenon and focus only on the experience as described by the participant (Moustakas, 1994; Polkinghorne, 1989).

Phenomenological descriptions differ from those in other qualitative research methodologies in that they are descriptions of people’s experience, not the objects of the experiences. Descriptions in phenomenology will be descriptions of the experiencing of an external reality, not a description of the ‘real’ world because we can only know of the world through our experiences (Polkinghorne, 1989; Wrathall & Kelly, 1996). Phenomenological descriptions are also descriptions of *what* the participant experiences, not *how* or *why* they experience it. It is not about the construction of theory to explain the phenomenon; it is simply a description of the experience with all its textual qualities (Giarelli & Chambliss, 1988; Matthews, 1996; Moustakas, 1994; Neuman, 1998):

[Phenomenology] tries to give a direct description of our experience as it is, without taking account of its psychological origin and the casual explanations which the scientist, the historian or the sociologist may be able to provide. (Merleau-Ponty, 1962, p. vii)

From the rich descriptions of the experience, the phenomenological researcher should have a better understanding of what it means to experience the phenomenon under investigation. The *textual description* of phenomenology will be a description of the meaning that arises in consciousness (Polkinghorne, 1989). It is these meanings that constitute our subjective reality, our perceptions of all we experience.

There are three major issues that arise when undertaking research that seeks to discover meaning. The first is gaining access to the meanings that others make of experiences. Although a researcher can gain first-person reports of experiences, they can only be perceived in the second-person as the participant describes their meaning of the experience (Polkinghorne, 1989). Secondly, some would suggest that meaning does not reside *within* individuals, but rather *between* people, and as such, phenomenological methods do not adequately account for the locus of meaning (Driver & Scott, 1995; Wheatley, 1991). Finally, questions about meaning do not solve problems or address issues of inequity or justice, but they do lead to quality descriptions which give meaning to the particular phenomenon, and issues can be addressed subsequently (Smythe, 1997). However, with its focus on meaning-making, phenomenology does allow us to more readily empathise with the meanings of others, and better understand what it means to experience the phenomenon of interest.

Polkinghorne (1989) noted the need to understand experience *per se* in phenomenological research:

Phenomenological research methods... feature on human awareness and remind us that the research journey needs to attend to the configurations of experience before moving on to assumptions about independent natural objects. Because the descriptions of natural objects are derived from experience, experience itself must be clearly understood before a firm foundation can be established for the sciences studying the natural world. (p.41)

There are certain features that a focus on experience brings to phenomenological research. Phenomenology assumes that our experiences of the world and our “lived-through reality” will be different from our preconceptions of particular phenomenon, and therefore, the need to focus on experience itself (Smythe, 1997, p. 17). By centralising human experience, the phenomenologist includes all the data, as these are all important components of experience (Boud, 1993; Moustakas, 1994).

Finally however, the nature of this approach is that there are an inexhaustible number of experiences of any particular phenomena, as there is always another

way in which they can be perceived (Matthews, 1996). The challenge for the phenomenologist is therefore, to determine when sufficient and detailed enough accounts of a particular phenomenon have been collected, so that the essential qualities or essences of the experience can be determined.

## **Method**

The study was primarily qualitative in nature, although it did include some quantitative methods. Bogdan and Biklen (1998) suggested that qualitative and quantitative approaches can be used together, although “attempting to carry out sophisticated quantitative study while doing an in depth qualitative study simultaneously is very difficult” (p. 37). However, this project does incorporate some quantitative approaches which are added to complement the major focus on the qualitative methods (Gondoseputro, 1999). The mixed-method approach employed the various data collection methods which facilitated triangulation and a richer data set (Cresswell, 1997).

Further to the qualitative nature of the project, the study was longitudinal with data collection occurring over the period of one year. Longitudinal research enables patterns of development to be identified and responses to particular circumstances to be captured (Cohen, et al., 2000). The longitudinal nature of this study enabled the investigation of a range of mathematical experiences and associated beliefs, attitudes, values and feelings as the participants progressed through the initial stages of their teacher education programme (Ball, 1990; Cooney, et al., 1998; Gustafson & Rowell, 1995). A variety of methods were used for triangulation purposes and these are described in more detail further on in this chapter.

Given these methodological considerations, the method of the study will now be justified and described.

### *The Participants*

The participants in the study consisted of 31 preservice primary school teachers in the first year of their initial teacher education programme in New Zealand at a small independent institution in Tauranga. They were drawn from two student intake groups who undertook parallel programmes, which included a course in the teaching of mathematics during their first semester (course outline included in Appendix J). The demographic details of the participant group are displayed in Table 3.1. The participant group was characterised by a high proportion of female participants (84%) and a relatively low level of achievement in school mathematics (55% achieved no mathematics qualification at school).

Table 3.1: Participant Group Demographic Details

Age	Mean: 26 years Range: 17 – 45 years
Gender	Female: 26 Male: 5
Schooling	State: 23 Private: 6 Home: 2
Highest level of mathematics achieved	Year 10: 17 Year 11 (School Certificate): 10 Year 12 (Sixth Form Certificate): 2 Year 13 (Bursary): 2

As a lecturer in the course that the participants undertook during the study I was also a participant in some respects. It is relatively common practice for researchers in teacher education to investigate issues related to their own teaching as is indicated by the high proportion of such studies (at least 75%) listed in Appendix A. Also, pragmatic issues of access were diminished by working with participants on the same campus as myself. But perhaps more importantly, it was hoped that the findings would impact my own practice. In reporting on a study he undertook with his own students, Nash (2002) suggested that “academics have a professional responsibility to engage in critical reflection on their practice”, and studies like

this “should be seen as a contribution to a well-established and necessary tradition” (p. 177). To this end, this study was also a part of my own professional growth as a mathematics educator working with preservice teachers.

### *Schedule*

Table 3.2: Data Collection Schedule

<p><b>February &amp; March 2001</b></p>	<p><b>First phase of data collection</b>  <b>Focus:</b> Experiences of mathematics prior to teacher education.  <b>Procedures:</b> Questionnaire  Interviews  Class activities</p>
<p><b>June 2001</b></p>	<p><b>Second phase of data collection</b>  <b>Focus:</b> Experiences of mathematics during the course.  <b>Procedures:</b> Questionnaire  Interviews</p>
<p><b>November 2001</b></p>	<p><b>Third phase of data collection</b>  <b>Focus:</b> Experiences of mathematics on practicum.  <b>Procedures:</b> Questionnaire  Interviews</p>
<p><b>April 2002</b></p>	<p><b>Participant reflections on the data</b>  Procedure: Interviews</p>

### **Method of Preparation**

In preparing for the data collection phase of the study, two particular issues were addressed. Initially, the epoche process, where the phenomenological researcher prepares himself/herself as the *instrument*, is detailed. Secondly, the ethical considerations of the study are outlined.

### *Epoche*

Before proceeding with data collection in phenomenological research, the researcher is supposed to engage in an epoche process (Moustakas, 1994). Epoche

is the putting aside of preconceptions and prior understandings by the researcher so they can look afresh at the phenomenon of interest (Houlstein & Gubrium, 1994). It is a fundamental process of phenomenological research as it enables the researcher to focus on the experiences as described by the participants (Hitchcock & Hughes, 1995).

The process of epoche involves the researcher in self-reflection to identify personal biases and prejudices, which they then invalidate or inhibit to allow an unfettered view (Polkinghorne, 1989). Epoche allows a freshness to the perception of experience promoting a new consciousness of phenomenon:

... the Epoche gives us an original vantage point, a clearing of mind, space, and time, a holding in abeyance of whatever colours the experience or directs us, anything whatever that has been put into our minds by science or society, or government, or other people, especially one's parents, teachers, and authorities, but also one's friends and enemies. Epoche is entering a pure internal place, as an open self, ready to embrace life in what it truly offers. (Moustakas, 1994, p. 86)

Although the process of epoche appears to claim that the total removal of the subjective is possible, Moustakas (1994) goes on to suggest that this is not the case. He suggested that the researcher does not need to doubt the reality of everything, only that knowledge which would predispose the researcher to a predetermined perception of the experience. The process of being transparent and only looking with a genuine gaze is however, a difficult one, and it requires patience. It is also a process that Moustakas (1994) suggested is not confined to the preparation stage of data collection, for the researcher will continually need to attend to personal preconceptions through self-review and reflection. Although difficult, and unlikely to be achieved fully, Moustakas (1994) claimed that the cathartic procedure does have significant value in that it predisposes the researcher to 'truly' receiving and perceiving the views of others.

While the epoche process sounds important and desirable, it is questionable whether it is possible. A researcher may be able to articulate the views and beliefs that they knowingly hold, but there will be tacit knowledge and thoughts that will not be open for critical review. The research questions chosen will reflect the interests and experiences of the researcher and as such the focus of inquiry will



involve their beliefs, values, attitudes, feelings, knowledge and personal dispositions (Lincoln & Denzin, 1994). There is an assumption that once preconceptions are dealt with through logical review processes they will be bracketed and put aside throughout the study. However, life and feelings are such that they do not always follow a logical and uncomplicated sequence, and therefore, the researcher cannot hope to be neutral, naïve or completely impartial, even after rigorous self-review.

In the present study, I do not claim to be neutral or unbiased, but instead I have tried to have an *attitude of epoche* throughout the research process. To this end a journal was maintained in which I recorded any ideas, thoughts, reflections, preconceptions, feelings or views that I had throughout the study. Of course these were only the ones of which I was aware, but nevertheless it proved to be invaluable as a reference for when I might be:

- directing the participants towards certain responses;
- pre-setting the findings before the data analysis; and
- looking for simple, clean patterns in complex and messy data.

Also, regular discussions with professional colleagues, supervisors, students and friends aided in the process as they added other perspectives to the issues at hand. Furthermore, as someone who has always been relatively successful in my mathematics learning and positively predisposed towards the subject, the recording and setting aside of my own views seemed to allow me to have a more empathetic understanding of the experiences of the participants. While far from adequate, the epoche process assisted in maintaining quality during the data collection processes.

### *Ethical Considerations*

The primary ethical issue of the study arose from my relationship with the participants. I was one of the lecturers in the participants' preservice teacher education programme and in particular, I lectured in the course *The Teaching of Mathematics 1*. The procedures and decisions made to protect the participants from harm and to maintain the integrity of the study are outlined below.

Before the study began, the approval and informed consent was sought from the Dean of the institution where the study was undertaken. Furthermore, the study sought and received ethical approval from both the institute's Research Committee and the University of Waikato School of Education Ethics committee.

In inviting the students in the first year of the primary teacher education programme to participate it was made clear that involvement was entirely voluntary and optional. This was outlined orally and in the letter asking for their informed consent (see Appendix E). The student teachers who chose to participate (31 of the 45 invited) gave their informed consent by signing the appropriate form. These forms are stored in a secure place and they will be destroyed after five years. Furthermore, the data gathered throughout the project will be confidential to the researcher and the thesis supervisors. In collating and storing data, coding was used to provide confidentiality and anonymity for the participants and to this end pseudonyms were employed in the writing-up of the study. The person employed to transcribe some of the interviews signed a statement of confidentiality (see Appendix F) before beginning her task.

Of particular concern was the protection of the participants from harm that may have arisen from my dual role as researcher and lecturer in their tertiary programme. The student teachers were reassured that their participation or non-participation would have no bearing on their assessments during their tertiary study. As a lecturer in the *Teaching of Mathematics* course, I was not actually involved in any marking or assessing of the students' work and any views or opinions I had about the student teachers were not shared with the lecturer responsible for the assessment. If any of the participants felt compromised then they were able to take their concerns to myself, or the Dean of the institution or the President of the Student Association, who were able to deal with any issues confidentially. Fortunately, there were no concerns expressed by the participants during the study.

Finally, as well as being able to withdraw from the study at any time and take their data with them, the participants were also able to edit their data. To facilitate this process the participants were given their interview transcripts to review, edit

and/or correct with a letter again giving their consent for the data to be used in the study (see Appendix G). The participants were then given the opportunity to replace their original transcripts in the data set with the edited ones.

## **Method of Data Collection**

The study used a range of data collection methods to allow the participants to express their views and recount their experiences in different ways. The advantages of this were two-fold. Firstly, the participants may have had different preferences for how they liked to present their opinions, feelings and descriptions, and secondly, it provided a means of triangulation for the data. Before settling on the data collection methods, a range of other previous studies were reviewed (see Appendix A). The data collection methods employed were:

- Interviews
- Journal-keeping
- Activities that were part of *The Teaching of Mathematics 1* course including writing metaphors and drawing pictures.
- Questionnaires.

These methods are now discussed in turn.

### *Interviews*

A key purpose of the study was to explore the relationship between the participants' experiences and their beliefs, values, attitudes and feelings towards mathematics. To this end, Gondoseputro (1999, p. 494) suggested that interviews provide "a window through which to see beliefs". Interviews were widely used in a number of similar studies (Archer, 1999; Ball, 1990; Bobis & Cusworth, 1994, 1997; Carroll, 1994a, b; Cooney, et al, 1998; Gondoseputro, 1999; Gustafson & Rowell, 1995; Kaminski, 1997; Mewborn, 1999; Owens, et al, 1998; Perry, Howard & Tracey, 1999; Ruffell, Mason & Allen, 1998; Schuck, 1996, 1997b, 1998; Shield, 1999; Taylor, 1992; Tirosh, 2000; Van Zoest, et al., 1994; Wood, 2000; Wood, Cobb & Yackel, 1990). The phenomenological interview can generate rich and meaningful data as it focuses upon the experiences of the participants (Cohen, et al., 2000; Polkinghorne, 1989).

In phenomenological research the purpose of data collection is to obtain naïve descriptions of the participants' experiences. Although this can be done through a range of data collection methods it is predominantly done through interviews (Polkinghorne, 1989):

The qualitative research interview attempts to understand the world from the subjects' point of view, to unfold the meaning of peoples' experiences, to uncover their lived world prior to scientific explanations. The qualitative research interview is a construction site of knowledge. An interview is literally an 'inter view', an inter change of views between two persons conversing about a theme of mutual interest. (Kvale, 1996, pp. 1-2)

The phenomenological interview is more like a conversation than a formal interview. A conversation is more natural as it resembles everyday human interaction where people get to know one another as they share experiences, views and beliefs. Conversations however, tend to meander as they don't have a set purpose, whereas the phenomenological interview is directed in the sense that it has a purpose and an agenda. Also, in a conversation you have two or more people who share relatively equally in the dialogue, but in the interview the phenomenologist will want the participant to talk the most as he or she seeks to obtain a description of their experiences. This means that the researcher is cast in the role of listener and prompter, always receptive to whatever they are told (Smythe, 1997). Kvale (1996, p. 27) suggested that the qualitative interview should be "semi-structured: It is neither an open conversation nor a highly structured questionnaire".

In the phenomenological interview, participants are asked to describe in detail their experiences of the phenomenon of interest. To achieve this, interviews are usually open-ended and the interviewer's role is to maintain the focus on the events and life-world experiences of the interviewee(s) (Polkinghorne, 1989). The essential descriptions of experience will be about the participants' perceptions of what occurred and how they felt about the occurrence, rather than explanations of why it may have happened.

Interviewing is something of an art form, and good interviewers need to think, analyse, and react as they proceed through the interview. This requires that interviewers are knowledgeable about the topic and alert to the methodological choices available to them through the interview process (Kvale, 1996). During the interview researchers need to constantly monitor their own thoughts so they can maintain an openness and an unassuming disposition towards the descriptions of the participant, thus continuing the attitude developed in the epoche process (Moustakas, 1994). The interview should have a sense of warmth and genuine empathy, and if conducted well, it should be a mutually beneficial experience for both the researcher and the participant, allowing both to gain new insight into the topic from their own perspective (Kvale, 1996; Oakley, 1988).

Group interviews bring together people with varied experiences and this can generate interaction among the participants (Cohen, et al., 2000). The participants can stimulate one another to talk about the topic of interest and the interaction can lead to spontaneous and emotional responses as they share their lived experiences (Kvale, 1996). To achieve this however, the group interview requires skilful chairing and careful consideration of the room layout. Problems can arise when participants feel uncomfortable or exposed in front of their peers and some individuals can dominate the dialogue (Cohen, et al., 2000).

In the present study the interviews were conducted with groups of between two and five participants. Group interviews were undertaken on three occasions during this study with each round of interviews focussing on a particular realm of experience in mathematics education. The groups were self-selected by the participants who signed-in for a particular time on a booking sheet. The participants didn't seem to be particularly concerned about who else was in their group although some students booked en-masse for a specific time-slot. The interviews lasted between 25 and 70 minutes depending on the size of the group, the realm of experience under discussion and the willingness of the participants to engage in the dialogue. The features of group interviews outlined above were indeed evident during the interviews as the participants responded to one another as they shared their personal experiences of mathematics and mathematics education. Regularly they would comment on the similarities or differences in

their experiences and at times they would empathise and comfort one another as their emotions were stirred by their responses.

The interviews were semi-structured around the following questions:

- What were your mathematics classes like during [the period of interest]?
- What did you do during your mathematical experiences?
- How do you feel about your mathematical experiences?
- Is mathematics important? Why or why not?
- What is mathematics? Or, what do you think mathematics involves?

These questions were used to open up the dialogue on the topic, and prompts were used to follow-up their responses. The interviews did not always follow the structure above because at times the participants talked about a topic as they responded to one another and discussed the issues as they arose. However, as the researcher I also chaired and monitored the interviews to ensure the discussion kept within the broad parameters of the topic and that the themes expressed in the structuring questions were adequately covered.

All the interviews were audiotaped and transcribed by an independent person. The transcriber signed a statement of confidentiality (see Appendix F). Once transcribed, I listened to each tape in turn and followed the dialogue on the transcript, correcting any errors while again reliving the interview experience. The corrected transcripts were then returned to the respective participants with a covering letter asking them to read and edit their parts of the transcript and return them to me. Without exception the participants returned their transcripts unaltered.

### *Journals*

Several researchers have used participant journals as a data source when conducting studies similar to the current project (e.g., Bobis & Cusworth, 1994, 1997; Mewborn, 1999; Nesbitt Vacc & Bright, 1999; Owens, et al, 1998; Ruffell, et al, 1998; Schuck, 1997a; Schuck & Foley, 1998).

Janesick (2000) suggested that “journal writing is a rigorous documentary tool” (p. 392) through which researchers and participants can reflect on the topic of interest. Cortazzi (1993) also supported the use of personal journals as a means of promoting participant reflection, which then became available to the researcher as a lens on the topic of interest.

Artzt (1999) found that journal writing provided opportunities for student teacher participants to reveal their affective positions:

When student [teachers] are engaged in thinking and writing about their goals, their knowledge, and their beliefs in relation to their instructional practice, their motivational and dispositional factors became apparent. (pp. 160-161)

Schuck (1996) also found that reflective journals were useful as an instrument for data collection, but they were also powerful educational tools as preservice teachers examined new ideas against the background of their own schooling history. Furthermore, Gunstone & Northfield (1994) found that the benefits of journals for both learning and data collection were enhanced when prompts were used to guide student reflection.

While the benefits of reflective journals are evident, Nesbitt Vacc and Bright (1999) add a note of caution:

Considerable personal reflection on one’s beliefs and behaviour would seem to be necessary for one to develop coherent pedagogy; short reflective journal entries may not provide adequate opportunity for reflection. Other contexts for reflection ... may be necessary. It is not clear whether preservice teacher education programmes can structurally accommodate these needed ‘reflection events’. (p. 107)

While the importance of reflection in preservice teacher education programmes has been generally promoted recently, there is still considerable debate as to what it is and how it might be achieved (Norsworthy, 2001). Nevertheless, the data that can be generated through the journalling process can be rich, informative and reflective and therefore, it is worthy of collection (Artzt, 1999).

In the present study the participants were asked to keep a journal throughout the project. They were asked to record their reflections, thoughts, feelings and ideas as they related to their experiences of mathematics and mathematics education.

All the participants maintained a journal which was made available to the researcher at the end of the study. During the first five months of the project the journal they kept was an integral part of their course on the teaching of mathematics and their entries were often guided by questions or prompts presented by the researcher (see Appendix B). In the second half of the project, the participants were not formally studying mathematics education, but during this time they were asked to continue to write any of their thoughts, reflections or ideas about the topic in their journal. In particular, they were asked to consider their experiences of mathematics and their associated affective views during their practicum experience in a primary school classroom. It would be fair to say that the participants made very few entries in their journals in the second half of the study apart from their time on practicum.

As the period of data collection drew towards a close, the participants were asked to submit their journals. Before submitting them, the participants were told that they could delete any of their journal entries from the data for the project if they wished by removing the pages or stapling pages together and two of the participants chose to take up this option. The journals were then read and word-processed as computer files by the researcher, and the original journals were then returned to the participants.

### *Writing Metaphors*

The methods of the present study were employed to gain some insight and understanding into the beliefs, values, attitudes and feelings of the participants given their particular experiences. It has been suggested that metaphors can carry and convey peoples' beliefs and values (Munby, 1986; Sfard, 1998; Tobin, 1990). Furthermore, Lakoff and Johnson (1980) commented on the place of metaphor as people come to make sense of their experiences:

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 what we have in common with someone else, so we seek out personal metaphors to highlight and make coherent our own pasts, our present activities, and our dreams, hopes, and goals as well. (p. 232)



Hagstrom, Hubbard, Hurtig, Mortola, Ostrow and White (2000) also noted in their work that; “metaphors open the fresh space of truth-telling, humour, powerful use of language, and image that hold the paradox and complexity of the human experience” (p. 27). Thus, it appears that metaphors bring together the affective positions and views of a person and their understanding of their experiences. While there are limitations on the power and usefulness of metaphors, they have been seen as an appropriate medium for the promotion of reflection particularly on affective responses to experience (Hunt, 2001; Marshall, 1990; Munby & Russell, 1990). Furthermore, Carter (1990) adds that metaphors are valuable in communicating the meanings, beliefs, values and feelings a person assigns to a particular experience. A number of researchers have used metaphor writing as a data collection method to gain insight into their participants’ beliefs, attitudes, feelings (Carter, 1990; Davies & Savell, 2000; Fraser, 1999; Gibson, 1994; Hagstrom, et al., 2000; Marshall, 1990; Munby & Russell, 1990; Tobin, 1990). For the reasons outlined above, it seemed appropriate to invite the participants to write a metaphor as a mode of data collection for the study.

All the participants in the present study were also students in the course *The Teaching of Mathematics 1*, a foundational course in the first year of their preservice teacher education programme. In the third week of that course the student teachers were asked to write a metaphor or simile in response to the prompt; “For me maths is like ...”. I then asked the student teachers who were also participants in the study if I could copy their responses and use them as data in the present study and they all complied.

#### *Drawing a Picture of their Mathematics Teachers*

For many people their views about mathematics and mathematics education are significantly influenced by their school mathematics teachers (Carroll, 1994a; McLeod, 1992). The images preservice teachers have of mathematics teachers can powerfully influence their own development as teachers of mathematics and therefore, accessing these images can be helpful.

Although participant-generated visual images are not a common source of data in educational research, they have been used by some researchers in forms such as photographs and drawings (Bogdan & Biklen, 1998; Kellehear, 1993). Picker and Berry (2000) conducted a large-scale (n = 476) international study into students' images of mathematicians by getting participant drawings of mathematicians. In reviewing their study, they commented that:

In providing the images on our survey tool, we could not have anticipated how much pupils would provide a window onto their experiences in their mathematics classes. We believe that the drawings created by the pupils contain valuable insights with significant implications for teachers, their training and their practise. (p. 88)

In working with preservice teachers, Gunstone and Northfield (1994) also asked their participants to draw a picture of a teacher. This allowed the researchers access to some of the participants' preconceptions and beliefs about teachers and the practice of teaching.

In the present study, the participants were asked to draw a picture of their mathematics teacher. This picture could be of a particular teacher or an image that depicted the characteristics of their mathematics teachers. These pictures were done with black crayons on A3-size paper as an activity in the course *The Teaching of Mathematics 1*. The student teachers who were also participants in the study allowed me to photocopy their pictures. For ease of storage and handling, the pictures were reduced to A4-size and during the photocopying process all written references to actual teachers (e.g., teachers' names) were removed.

### *Questionnaire*

To complement the qualitative data a 25-item, seven-point Likert scale questionnaire was administered on three occasions to monitor changes in the participants' affective views. Questionnaires in this general form were commonly used in many of the previous studies in this field either as the sole source of data or in a mixed method study such as the present one (Ball, 1990; Biddulph, 1999; Bobis & Cusworth, 1994, 1997; Carroll, 1994a, b; Fennema, Carpenter, Franke, Levi, Jacobs & Empson, 1996; Grootenboer & Lowrie, 2002; Gustafson & Rowell, 1995; Joram & Gabriele, 1998; Mayers, 1994; Nesbitt Vacc & Bright, 1999; Owens, et al., 1998; Perry, et al., 1999; Relich & Way, 1992; Roberts,

Cretchley & Harman, 1998; Schuck & Foley, 1998; Southwell & Khamis, 1992; Way & Relich, 1993).

Cohen, et al. (2000) suggested that questionnaires are useful in gathering ordinal numerical data in a cohort study such as the present one. They add that such questionnaires are often easy to administer and can be relatively straightforward to analyse. Furthermore, Burns (2000) noted the added advantages of the participants all receiving an identical set of questions and their responses not being influenced by the personal qualities, style or mood of the interviewer. However, these positives are offset by a questionnaire's limited capacity to capture the complexity and sophistication of the phenomena of interest. In the present study the qualitative methods were able to *flesh out* the data obtained through the questionnaire.

The design and structure of a good questionnaire is determined by the question(s) being investigated and the nature of the data being sought (Davidson & Tolich, 1999). Likert scale-type questionnaires are generally considered to be quick and straightforward to complete and they do not discriminate unduly against those who are less articulate (Cohen, et al., 2000). For the purposes of this study, the questionnaire was used to generate numerical data that indicated the participants' affective views at various times.

In designing the questionnaire, several factors were considered. Firstly, the questionnaire was only one of the methods of data collection employed in the study and therefore, it did not need to be comprehensive in its scope. This meant the questionnaire could be based on Likert scales that produced numerical data, as more fulsome details were explored through other methods. Secondly, the questionnaire was to be administered on three occasions, therefore, the item-prompts needed to be general enough to apply to all the time periods. Finally, the participants had already given a significant amount of their time to the study in the interviews and therefore, the questionnaire needed to be relatively quick to complete and hence the use of a 25-item Likert scale questionnaire.

Before writing the items for the questionnaire, a number of other studies that considered the affective domain (or some aspect of it) in mathematics education using Likert scale questionnaires were reviewed (e.g., Bobis & Cusworth, 1997; Fennema, et al., 1996; Nisbet & Warren, 2000; Owens, et al., 1998; Relich & Way, 1992; Warren & Nisbet, 2000). The items for the current study were then developed with some coming directly from these other instruments and others being written to more closely meet the project's requirements. The items were then reviewed by experienced colleagues and modified on their advice. The items were randomly ordered and some items were negatively loaded to avoid participants carelessly responding without reading the prompts thus increasing the instruments reliability and validity (Burns, 2000). The final questionnaire consisted of 25 items that required a response on a seven-point Likert scale (see Appendix C). Participants were able to make additional comments on the questionnaire if they wished.

The questionnaire, which was originally designed for this study by me, was subsequently used in another study (Grootenboer & Lowrie, 2002) and the results reported prior to the completion of this thesis. However, it was employed in a slightly different way. The questionnaire was administered to 167 preservice teachers in Australia and New Zealand and the resulting data was investigated using factor analysis and multivariate analysis. While the findings of the earlier study are not directly linked with the present one, it is worth noting that the data yielded by the questionnaire was statistically robust and theoretically sound.

As outlined in the data collection schedule (Table 3.2, p. 48), the questionnaire was administered on three occasions during the study. The first time (February) was at the beginning of the study and the participants responded based on their school experiences of mathematics. The second time (June) followed their experiences in the course *The Teaching of Mathematics 1*, and the third (November) came after their school-based practicum experience. On each occasion, the participants completed the questionnaire at the conclusion of one of their lectures. Although the participants may have been a little tired at the end of a lecture, it was a convenient way of accessing the whole participant group in one

place at one time. Generally it took the participants between eight and 15 minutes to complete.

## **Data Analysis**

The mixed-method design of the study yielded two distinct sorts of data and although each of the data sets informed and related to the other, they were analysed in different ways. The method of analysis for the quantitative data is outlined first, followed by details of the qualitative data analysis.

### *Quantitative Data Analysis*

As an initial step in the analysis of the quantitative data, all the participants' questionnaire responses were entered into a spreadsheet. At this preliminary stage the researcher spent some time just exploring the data and looking for patterns. This was followed by a more formal analysis of the data, firstly, by using statistical measures to explore differences between the three occasions that the questionnaire was administered, and secondly, by investigating particular items in the questionnaire.

To explore the differences between the participant-group responses on the three occasions that the questionnaire was administered, an ANOVA was performed followed by t-tests. To prepare the data for these statistical procedures, the scores for negatively loaded items in the questionnaire were reversed (i.e., 1 replaced by 7, 2 replaced by 6, 3 replaced by 5, 5 replaced by 3, 6 replaced by 2, and 7 replaced by 1). Each of the participants' responses were then aggregated to produce a total score on the questionnaire (minimum 25, maximum 175) where the lower totals represent a more positive affective view of mathematics and mathematics education.

The one-way repeated measures ANOVA was employed as the participants completed the same questionnaire on three occasions to explore any significant differences among the three sets of scores (Pallant, 2001). Once the ANOVA technique identified a significant difference among the three sets of scores, t-tests were employed to identify where those differences occurred.

A paired-samples t-test was applied three times to identify any significant differences between the three sets of scores (i.e., Time 1 to Time 2, Time 2 to Time 3, and Time 1 to Time 3). The two variables for the t-tests were time and questionnaire scores. Time was the independent variable (e.g., Time 1, Time 2, and Time 3), and the questionnaire scores was the dependent variable. After performing the t-tests, an effect size statistic (eta squared) was calculated to indicate the magnitude of the difference between the two sets of scores. While the ANOVA and t-tests were performed using the SPSS program, the eta squared statistic was calculated using the formula below:

$$\text{Eta Squared} = \frac{t^2}{t^2 + N - 1}$$

In interpreting the eta squared values the following guidelines were used: 0.01 = small effect, 0.06 = moderate effect, 0.14 = large effect (Pallant, 2001).

Further analysis was undertaken to investigate any possible differences between groups of participants based on their initial responses to the questionnaire. The participants were divided into three equal sized groups corresponding to those who responses were initially the most positive (PG), those who were most negative (NG) and those in-between (called the ambivalent group, AG). The mean and standard deviation was then calculated for each group for each application of the questionnaire and the data was also graphed to reveal any patterns. Finally, the mean score was calculated for each item in the questionnaire over the whole study for each particular group. This was done to see if there were any particular items that were prominent for any particular group.

#### *Qualitative Data Analysis*

While the present study has sought to understand the phenomenon of interest through the participants' experience, it is not purporting to distil the essential qualities of mathematics learning as is the hallmark of a *pure* phenomenological study. Rather, phenomenological techniques were employed in both the data collection and data analysis phases of the study.

Initially, a great deal of time was spent reading and re-reading the data, listening to the audio-tapes of the interviews and looking at the pictures the participants had drawn to try and get an overall feel for the phenomenon (Patton, 1990). While this was a time-consuming task, it was an invaluable process in trying to empathise with the experiences of the participants and to see their mathematical experiences as they had described them. While this was being undertaken, I entered all of the journal and interview transcripts into the NUD\*IST program (Qualitative Solutions & Research, 1997) and in the process reviewed them again.

The data was coded from *the bottom up* by paying close attention to the empirical data (Rieman, 1998). The data was stored as text units that were either a sentence or a short paragraph, and then each text unit was coded. Initially the units were coded into categories that characterised their context, nature, theme and content, and therefore, many were coded several times. The following example indicates the coding process:

Text: “At secondary school we always worked from textbooks.”

Coding Categories: Secondary school, textbooks, and learning mathematics.

There was no attempt made to structure or organise the initial categories until after all the data was coded for the first time. This was done so each data unit could be dealt with *on face value* and to avoid premature decision-making regarding the nature and structure of the data.

After the initial coding was complete, the themes that emerged were reviewed in order to explore any patterns, clusters or links. After a preliminary structure was developed, the raw data were then revisited to check the validity of the themes and to check for any omissions or contradictions (Rieman, 1998). At this stage the emerging findings were also compared with the quantitative data to search for common issues and themes, and for triangulation purposes.

The next phase in phenomenological research is the development of a *textural description* and a *structural description* of the phenomenon (Creswell, 1998). The

textural description is created by aggregating all the thematic clusters to give an overall depiction of the *textures* of the experience. The result of this process is a description of what the phenomenon is, incorporating all its essential qualities (Moustakas, 1994). The structural description is also developed to express how the participants experienced the phenomenon. To do this, Moustakas (1994) suggests that the researcher needs to consider and explore reflectively all the possible meanings of the phenomenon by looking, and re-looking at the topic from many frames of reference. During the crafting of these descriptions the researcher needs to be continually refocusing on the themes as they appear in the participants' perceptions in the data, and not on how the researcher believes they should be. It is suggested that in this way the epoche phase is continued throughout the entire research process, helping make the experience "anthropologically strange" to the researcher (Hitchcock & Hughes, 1995, p. 176).

However, in the current study the phenomenon of interest did not lend itself to the descriptions as required for pure phenomenological research. Experiences of mathematics and mathematics education are contextual and while they may have some things in common, they do not seem to have an essence that pervade all experiences of the event (Grootenboer, 2000). It seems as if mathematics education is not a phenomenon, but rather a collection of phenomena that defy a common, universal essence. For these reasons, the data analysis in the present study departed from the pure phenomenological requirements for a description of the essential invariant qualities of the participants' experiences of mathematics education, and instead sought to capture the textures, forms and factors that were evident throughout the data.

After the qualitative data was analysed in the global sense outlined above, it was then revisited to consider the changes in the participants' experiences and affective views as they progressed throughout the study. During this analysis phase, the data was considered in the context of the three occasions of data collection (see Table 3.2: Schedule of Data Collection), and it was considered alongside the findings from the quantitative data. In essence, the qualitative data was re-coded and analysed to try and *give life* to the quantitative findings. As a final act in this phase of the data analysis, the participants were shown some of the



results and asked to interpret the data themselves, and in doing so they were also undertaking data analysis and generating more data.

## **Chapter 4: Quantitative Data**

Although the study was primarily qualitative, some quantitative data was collected to identify and monitor any changes in the sample group's views. The statistical data has been used to identify change and in Chapters 5 and 6 these changes will be elaborated upon with the qualitative data. The quantitative data was collected through the "Beliefs, Values, Attitudes and Feelings about Mathematics" questionnaire that was administered on three occasions as outlined in the schedule (Table 3.2, p. 48). The first occasion related to the participants' school experiences of mathematics, the second to their course experiences on the teaching of mathematics, and their third responses were after they had experienced mathematics education on their school-based practicum. Primarily the data analysis was undertaken using the SPSS program.

This chapter explores the data in three ways. Initially it examines statistically the aggregated results of the questionnaires to explore changes in the participant group as a whole. Secondly, the data is partitioned into three groups based on the participants' responses to the first questionnaire and patterns are investigated in a general sense. Finally, the individual items in the questionnaire are presented in a descriptive manner, and items which seemed significant are identified and discussed.

### **Changes in the Group over the Project**

The data for this section came from the participants' aggregated scores on the questionnaire. Two of the participants did not complete the questionnaire on all three occasions so their data were excluded. Before aggregating the scores, the responses to the items with negative loading were reversed. For each time the participants completed the questionnaire the minimum possible total was 25 (25 ratings of 1) and the maximum possible total was 175 (25 ratings of 7). The lower scores indicate a positive view about mathematics and the higher scores indicate a more negative view. This section will begin with the findings of the one-way analysis of variance (ANOVA) that was employed to identify differences between

the participants' responses at the three times the questionnaire was undertaken. Second, t-tests were used to examine the differences between the three occasions the questionnaire was administered. Third, the aggregated data from the questionnaires is displayed using a box plot to highlight the changes in the data over the period of the study.

#### ANOVA

A one-way repeated measures ANOVA was conducted to compare scores on the "Beliefs, Values, Attitudes and Feelings about Mathematics" questionnaire at Time 1 (relating to their school experiences), Time 2 (following their experiences in the course *The Teaching of Mathematics I*) and Time 3 (following their school-based practicum). The means and standard deviations are presented in Table 4.1. There was a significant effect for time, Wilks' Lambda = 0.421,  $F(2, 27) = 18.56$ ,  $p < 0.001$ , multivariate eta squared = 0.58.

Table 4.1: Descriptive Statistics for the "Beliefs, Values, Attitudes and Feelings about Mathematics" questionnaire for Time 1, Time 2 and Time 3.

Time Period	N	Mean	Standard Deviation
Time 1 (relating to their school experiences)	29	95.76	24.55
Time 2 (following their experiences in the course <i>The Teaching of Mathematics I</i> )	29	67.17	14.43
Time 3 (following their school-based practicum)	29	79.24	20.14

#### T-Tests

Paired-samples t-tests were conducted to evaluate the differences between the participants' scores on the three applications of the "Beliefs, Values, Attitudes and Feelings about Mathematics" questionnaire. There was a statistically significant decrease in the questionnaire scores from Time 1 to Time 2,  $t(28) = 5.71$ ,  $p < 0.001$ . The eta squared statistic (0.54) indicated a large effect size. There was a statistically significant net increase in the questionnaire scores from Time 2 to Time 3,  $t(28) = -4.16$ ,  $p < 0.001$ . The eta squared statistic (0.38) indicated a large

effect size, though smaller than the decrease from Time 1 to Time 2. There was a statistically significant decrease in the questionnaire scores from Time 1 to Time 3,  $t(28) = 3.37$ ,  $p < 0.01$ . The eta squared statistic (0.29) indicated a large effect size.

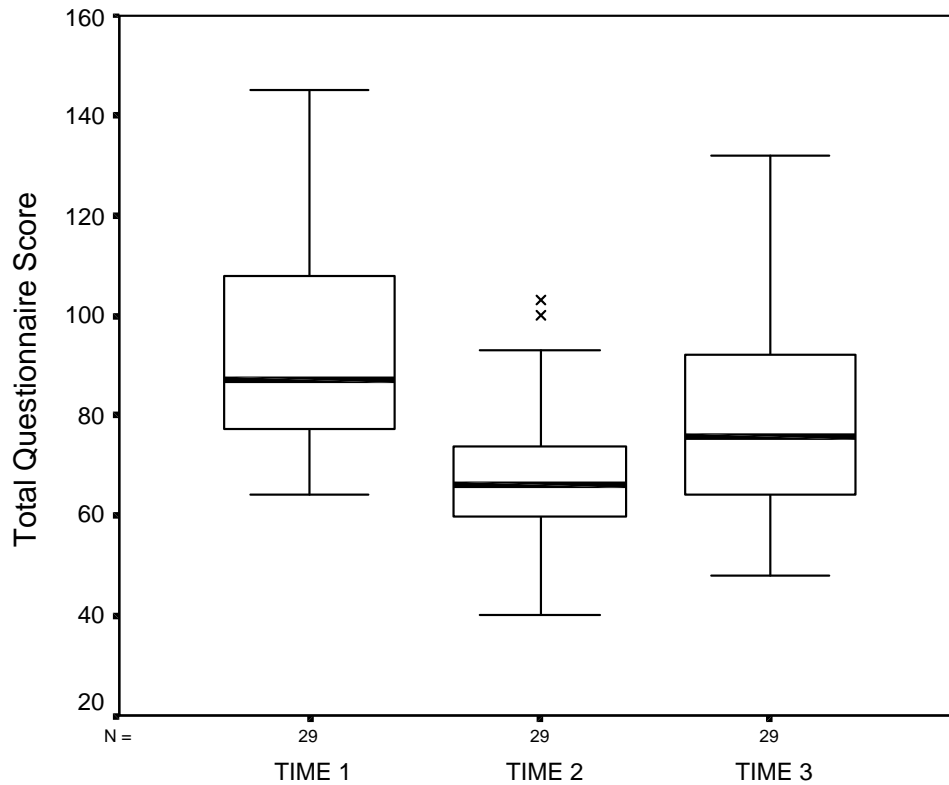


Figure 4.1 Boxplot of the total questionnaire scores

### *Summary*

The data presented in this section indicated significant changes in the participants' affective responses over the period of the study. The ANOVA analysis identified a significant change in the participants' scores on the questionnaire over the three time periods, but does not identify where the changes have occurred. The t-tests identified a significant change in the participants' responses between each of the times they completed the questionnaire. In particular, the participants' responses were significantly more positive after their tertiary course on the teaching of mathematics than they were when the participants considered their school experiences. However, their responses were more negative after their school-based practicum experience than they were after the course, but not as negative as

they had been initially. These findings are displayed clearly in the boxplot (Figure 4.1).

In essence, the data seemed to indicate quite strongly that the participants' tertiary course in the teaching of mathematics significantly improved their affective views towards mathematics, but some of these gains are lost through the school-based practicum experience. The reasons for these changes will be explored in the following chapters where the qualitative data is explored.

#### *Participants' Reflections on the Quantitative Data*

In April of the year following the study the participants were shown the aggregated quantitative data from the study and asked to comment. The data was presented as a simple line graph (see Figure 4.2 below) as it clearly showed the trends that occurred through the three phases.

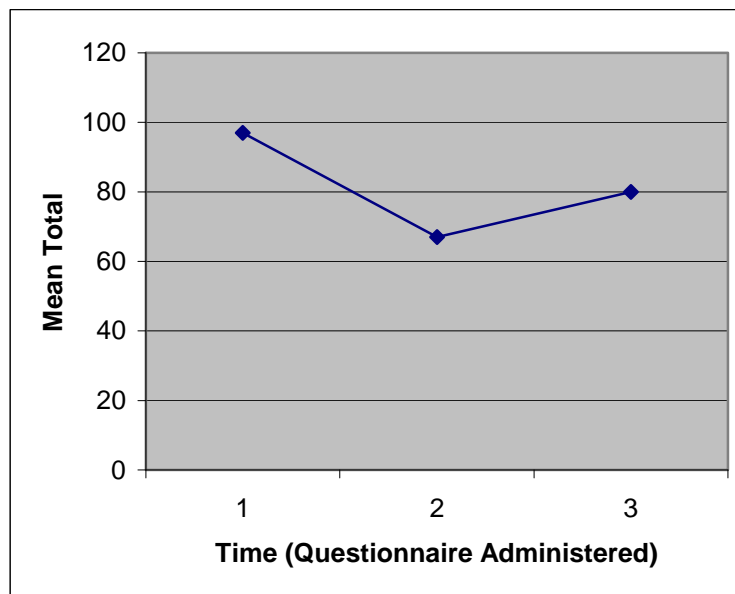


Figure 4.2 Line Graph of Mean Questionnaire Data

The participants were given a copy of the graph with a brief explanation and asked to write down their thoughts on the paper provided (see Appendix H). After completing the task some of the participants wanted to discuss the trends they observed in the data and a few then added further comments on their sheet. While this data is largely qualitative, it is included here as it focuses on the participants' interpretation and reflection on the quantitative data. At this point only the data

that relates to the trends of the data over the three phases will be addressed as the reasons for their views at particular times is discussed in the next chapter.

Of the 23 participants who completed the task, just over half (14) suggested that the sharp improvement in their affective views between Time 1 and Time 2 was due primarily to the difference they perceived between their school mathematics teachers and their course lecturers. Many of the participants (15) commented that the course had given them confidence and hope, as illustrated by Karen's comments:

The course and the lecturers gave us hope that maths can indeed be interesting and exciting with alternative teaching methods than those in our own experience. I felt confident that maths was different and I could teach it in an interesting way.

In reflecting on the overall decline in the participants' affective views about mathematics between Time 2 and 3, the general consensus seemed to be that the reality of classroom life was that it wasn't possible to make mathematics interesting and relevant. The pressure and direction from their associate teachers was towards a more traditional view of mathematics and hence they seemed to lose some of their hope and confidence. Felicity suggested that "perhaps the teachers at school had mindsets that limited the student teachers", and Josh thought that "the decline after practicum could have been due to witnessing boring maths in the classroom, which was a return to the maths they themselves experienced".

### **Changes in Particular Groups over the Project**

After the broad statistical analysis of the data reported above, the data was partitioned into three groups based on the participants' initial responses to the questionnaire. The groups represented those who were the most positive (PG), the most negative (NG), and the ambivalent group in-between (AG) and the data was explored to see if there were any differences in the patterns of their responses throughout the project. The data is presented on the following page in three side-by-side graphs (Figure 4.3) which show the patterns of their responses. The scores of individual students are represented by dashed lines and the group mean is

represented by a solid line. The mean scores and standard deviations for each group are also shown in Table 4.2 below.

Table 4.2: Mean and Standard Deviation of the Group Scores

Group	Time 1	Time 2	Time 3
PG	M = 73.0 SD = 5.5	M = 65.7 SD = 6.7	M = 68.5 SD = 12.1
AG	M = 89.9 SD = 7.4	M = 65.1 SD = 10.6	M = 82.3 SD = 15.9
NG	M = 127.7 SD = 13.2	M = 71.1 SD = 23.0	M = 87.8 SD = 27.1

The data presented in both the graphs and the table support the general pattern of the first section of the current chapter where the participants' responses are all (apart from one participant) more positive at Time 2 than Time 1, and the general trend is back towards less positive at Time 3 than Time 2. The global picture of the graphs in Figure 4.3 is that the PG was relatively stable in their views, the AG more prone to changes in their views and the NG exhibited large shifts in their responses. Furthermore, the data highlights the impact the significant positive changes the NG reported in their affective views towards mathematics between Time 1 and Time 2 – the period that corresponded to their initial tertiary course in mathematics education.

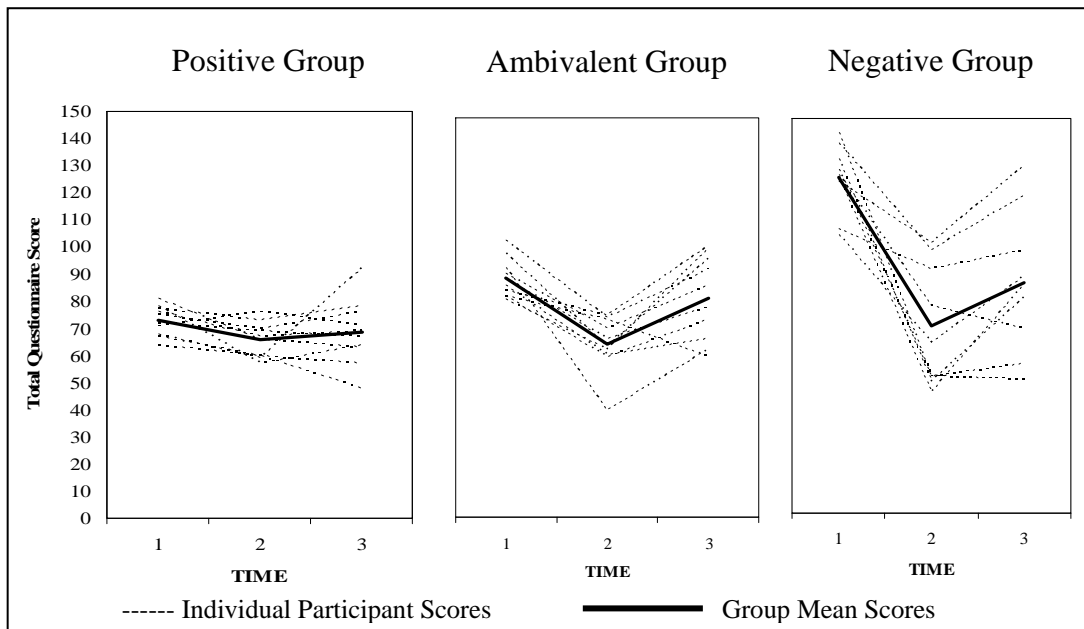


Figure 4.3: Group Responses to Individual Questionnaire Items

#### *Group Responses to Individual Questionnaire Items*

After exploring the data by aggregating the scores for each time the questionnaire was administered (i.e., Time 1, Time 2, Time 3), the data was then investigated item by item. Five items revealed interesting statistics, three where the difference between the PG and the NG was greater than 2-points, and two where the results appeared to go against the trends. The mean scores for these items are displayed in Table 4.3 below.

Table 4.3: Group Mean Scores for Certain Questionnaire Items (The items marked \* were negatively loaded)

Questionnaire Item	PG	AG	NG
3. I have a positive attitude to mathematics.	2.59	3.47	4.68
12. All students can enjoy mathematics.	2.24	2.73	4.26
25. I feel anxious about mathematics.*	4.83	3.4	2.06
19. If you understand mathematics then you can always solve problems quickly.*	2.28	3.03	2.53
20. A good thing about mathematics is that it is an unchanging subject.*	3.69	3.47	3.71

The results indicate, not surprisingly, that the PG had a more positive attitude to mathematics, were less anxious about mathematics, and were more likely to think



that all students could enjoy mathematics, than the NG. The sum of these results seems to indicate that the PG generally had better feelings and attitudes towards mathematics.

The last two items in the table revealed that PG and NG were fairly consistent in seeing mathematics as an unchanging subject, and the PG was more likely to think that those who understand mathematics can solve problems quickly. These items indicate that those in the PG seemed to have an infallible, unchangeable perspective on mathematics.

#### *Responses to the Individual Items in the Questionnaire*

Due to the small size of the sample and the non-parametric nature of the data it was not appropriate to undertake a statistical analysis of the responses to the individual items in the questionnaire. However, the descriptive statistics, which are only indicative of central tendency, are shown in Table 4.4 below.

Table 4.4: Mean Responses to Individual Questionnaire Items

Questionnaire Item	Time 1	Time 2	Time 3
1. I believe that mathematics is important.	2.19	1.71	2.24
2. I appreciate the value of mathematics.	3.48	2.35	2.62
3. I have a positive attitude to mathematics.	4.65	3.23	3.07
4. I enjoyed my experiences of mathematics.	5.23	1.87	3.48
5. I believe that mathematics can enhance my life.	4.08	2.81	3.00
6. My experiences have prepared me well to use mathematics in my life.	4.92	2.74	4.28
7. Mathematics is primarily concerned with arithmetic.	3.66	2.68	2.86
8. A person is either good at mathematics.	3.74	2.26	2.90
9. You don't understand mathematics, you just do it.	3.08	1.77	2.07
10. Mathematics can be exciting and interesting.	3.03	2.39	2.79
11. All students can achieve in mathematics.	3.42	2.48	2.86
12. All students can enjoy mathematics.	3.60	2.55	3.34
13. Mathematics is a solitary activity done in isolation.	2.71	1.42	1.45
14. Mathematics has little to do with real life.	3.60	2.35	2.83
15. The advantage of mathematics is that things are either right or wrong.	4.32	2.94	3.28
16. Mathematics is a creative and dynamic	4.61	2.97	3.93

activity.			
17. Mathematics involves memorising rules and applying them mechanically to solve problems.	4.65	3.32	3.52
18. Mathematics education needs to go back to the basics.	4.85	4.32	4.41
19. If you understand mathematics then you can solve problems quickly.	4.89	3.68	4.59
20. A good thing about mathematics is that it is an unchanging subject.	3.56	2.48	3.10
21. Students learn mathematics best through exercises and plenty of practice.	4.95	3.55	4.31
22. Mathematics is primarily about computation.	3.68	2.71	3.69
23. Mathematics education involves exploring things in the world outside school.	3.52	1.90	2.34
24. Children should use concrete materials in mathematics.	3.13	3.10	2.76
25. I feel anxious about mathematics.	4.11	3.39	3.52

While it is not valid to read too much into the information in Table 4.4, it does show some interesting patterns. With only a few of exceptions, the responses to each individual item are most negative at Time 1 and most positive at Time 2, and this reinforces the pattern identified previously. Items 4 (*I enjoyed my experiences of mathematics*) and 6 (*My experiences have prepared me to use mathematics in my life*) show the greatest distinction between the times the questionnaire was administered following the aforementioned pattern. The participants' responses to Item 22 (*Mathematics is primarily about computation*) indicated that their views were more positive at Time 2, but reverted right back to their original views at Time 3. Of final note are the consistent responses to Item 1 that indicated that the participants always saw mathematics as relatively important, despite their other feelings or views of the subject.

## Summary

The quantitative data revealed significant changes in the participants' affective responses to mathematics over the three phases of the study. Overall, the participants' affective views about mathematics were significantly more positive after their tertiary course than they were after their own school experiences.

However, after their school-based practicum experience, the negative group's views had returned somewhat towards their initial views. The trends indicated by these results were clearly visible in the graphs shown in Figures 4.2., 4.3 and 4.5. Of the participants, those with an initially positive perspective of mathematics were more stable in their views, whereas those who were initially negative varied more significantly. The qualitative data presented in the next chapter will explore, describe and discuss some of the reasons for the changes in the participants' views.

## **Chapter 5: Qualitative Data**

In this chapter the qualitative data from the interviews, participant journals and the class activities are explored and described. The data were multi-layered and intricately inter-connected, but for the purposes of this chapter categories from the data are used to present the main findings beginning with the participants' experiences as school pupils. The data was coded using the NUD\*IST program (Qualitative Solutions & Research, 1997) and the categories emerged as the data was explored and coded. Initially, the participants' experiences as school students are presented. This is followed by a description of their experiences in the first year of their preservice teacher education programme and then thirdly, their affective responses to mathematics and mathematics education are outlined. Finally, some other themes that emerged throughout the different sections are briefly discussed. Throughout the chapter the participants' own words are used extensively to illustrate themes and categories in an attempt to capture their perspectives of the experiences and topics of interest.

### **Experiences as School Students**

The first phase of data collection for this study focussed on the participants' experiences as school students. In some ways these data were different from the other data in the study because these were, to a certain extent, fixed in memories of past experience whereas the other phases revealed more dynamic issues inasmuch as they dealt primarily with their current experiences. The data were based around two main contexts, namely primary schooling and secondary schooling, with secondary school experience being the most salient. It seemed as if their recollections of secondary mathematics were more prominent because of recency, but also because mathematics was a more easily defined subject with a particular mathematics teacher in a particular mathematics classroom. The participants' experiences of mathematics at primary school are presented, followed by their experiences at secondary school.

## Experiences at Primary School

For many of the participants, primary school mathematics lessons were a distant memory, which they often struggled to distinguish from learning in other subject areas. However, after some time and group discussion (a method that seemed to facilitate recollection of prior experience) the majority of the participants could recall aspects of their primary school mathematics classes and by far the most salient memory was of “times-tables”. For example, Myra commented in her first interview:

*I don't remember much of my primary school maths except times-tables. We used to have a competition going to see who could be the fastest and get the most right. Yer – times-tables were the most important thing we did in primary school. (Interview 1.3)*

A number (13) of participants with varying ages and backgrounds made comments similar to Myra's above concerning times-tables. A later section will present this finding in more detail.

In describing their mathematics lessons at primary school, features that emerged were the time and place of their lessons, the equipment and books used, and the tests and quizzes they had. It seemed as if most of the participants had their mathematics lessons in the morning either after “news-time” or straight after morning interval and many of the lessons were based around “the mat”. Brad wrote in his journal:

*I can still vividly remember sitting on the mat in primary school with a teacher called Mrs Crabb. We were in Room 3 and everyday we would come in, have a talk for a while as a class and then get into our maths. This would entail the whole class sitting around in a circle on the mat and by clapping our hands and clicking our fingers in a rhythmic pattern we would chant our times-tables. I also remember doing pages in our workbooks of exercises and questions that the teacher would set from the green textbook.*

The quote above from Brad's journal also highlights the use of textbooks and work or exercise books, which was noted by a number of participants (7 of the 31) in their recollections of primary school mathematics. A few participants (6) also

remembered using equipment in their mathematics lessons, including Cuisenaire rods, counters, rulers (for counting on) and Deine's blocks.

Another feature mentioned by some (8) of the participants was "mental" which referred to a quick quiz of about ten questions that they had to calculate "in their head". The participants who noted these mental arithmetic quizzes suggested that they were an integral part of every mathematics lesson and some also remembered having a test every Friday. In their descriptions of these quizzes and tests, times-tables were again often cited. The underpinning theme to all the participants' descriptions of their primary school mathematics curriculum was arithmetic. For many of them, this was seen as "the basics" and an important foundation stone of their overall education.

The majority of the participants (29) expressed a general enjoyment of their primary school mathematics lessons (with only two of them explicitly stating unpleasant memories). An example of such a positive recollection comes from Renee:

*In primary school ... we had all sorts of different fun activities as well as doing work out of books. Like we had one teacher who put a clock-face on the board but changed the numbers around and then made us do our times-tables from that and you had to get it under like 30 seconds to go up to your next times-table and that was a lot of fun. I remember learning a lot and the games were enjoyable so that made maths fun! (Interview 1.5)*

A number of the participants (12) mentioned that the use of games made their mathematics learning enjoyable as exemplified by Renee's quotation above. Often the games they described involved some sort of class competition and usually they involved arithmetic or times-tables. Others reported that they were also allowed to play mathematical games when they had finished their set work for the lesson, and this reward was perceived positively.

For the two participants who disliked their primary school mathematics there were some common features to their experiences. In both Mike (aged 36) and Caitlin's (aged 17) case, their primary school experiences were critical in establishing their views about mathematics and themselves as mathematics learners, and they

reported that these views impacted all their future mathematics education. For Mike it was a critical moment in Standard One (age 8) and his story is more fully explored in a later section (Critical Moments), but for Caitlin the memories were of a continuous experience of failure and embarrassment:

*I pretty much hated my mathematics classes all through primary school. I can still remember trying to put the numbers from 1 to 100 in the right order and being stood up in front of my entire class to do it when I didn't have a clue. And then it was like; "You didn't do that number right. Bad girl, blah, blah, blah". And then out to the principal's office. And that was my first memory of maths and then after that it was just like my brain switched off and I hated maths. Like times-tables; "Stand up and get this times-table right". "But I don't know it!". "But you have to know it. ra, ra, ra, ...Count on your fingers! Count on your ruler! Whatever, just get it right".*

*So you know, after that I just switched off and failed every year. (Interview 1.5)*

While Caitlin's perceptions of her experiences of primary school were mostly different from the rest of the participants, the impact they had on her was significant. Again times-tables featured in Caitlin's description, and this was a common theme throughout this section on experiences of mathematics at primary school.

### *Times-tables*

As mentioned at the outset, the dominant theme through all the data relating to the participants' primary school mathematics education was times-tables, with 23 of the participants referring to them in their journals and/or interviews. Participants would commonly recall learning their times-tables by singing or chanting them as a class, and they reported that the purpose of such songs and chants was to "memorise them". A number of them (8) thought the rote learning they underwent was "good because they stuck!" (Darlene, Interview 1.2). It appears that many of the participants had a regular times-tables test and poor performance on the test meant they had to write them out several times afterwards. For Emma "every

lesson [at primary school] was the same old, same old - times-tables, times-tables, times-tables and then a test” (Emma, Interview 1.6).

A feature of many of the participants’ experiences were competitions where students said or wrote their times-tables as quickly and accurately as they could. Quite a few (9) thought these competitions were fun and enjoyable and often they were the ones who performed in such events well. Others (6) reported negative memories of these competitions because they were unsuccessful and they felt embarrassed and/or shamed in front of their peers. Furthermore, their success or failure in memorising their times-tables seemed to be a significant factor in their perception of themselves as mathematics learners generally. This can be seen in the contrasting comments made by Grace and Warren below:

*... You know, honestly I am no good at maths - I don’t even know my times-tables. At [primary] school I was hopeless at my tables and I still don’t know them. (Grace, Interview 1.1)*

*Well I loved maths at primary school. I picked it up really easily and I knew all my tables by Standard 4 so I usually won the times-table around-the-world competition. ... (Warren, Interview 1.5)*

For most of the participants, times-tables were the dominant and most significant memory and perception of their primary school mathematics education and as illustrated above, their ability to memorise their tables was a major determining factor in their perception of their success and ability. However, participants never mentioned times-tables as part of their secondary mathematics education other than to suggest that they struggled because they hadn’t learned their tables at primary school.

## **Experiences as Secondary School Students**

All of the 31 participants were able to recall in some detail their experiences in mathematics classrooms at secondary school. Their reports included particulars of the lesson content and structure, assessment practices and their own achievement, rich descriptions of their mathematics teachers including personal details, and their feelings and attitudes associated with their experiences. Perhaps notable by



their omission were references in the data to particular mathematical topics such as algebra or statistics. Only one participant mentioned learning algebra, and two noted experiences with trigonometry, and in each case they perceived their learning in these topics as being irrelevant, difficult and unsuccessful. Overall, the most significant recollections were related to their mathematics teachers and often when the participants were asked to comment about their mathematical experiences at secondary school their response was about their teacher. Joanna, a mother in her mid-thirties commented in her journal:

*My most vivid recollection of secondary school mathematics is probably the teachers that I had. I don't remember the maths so much but the teachers!*

A striking feature of the data was the predominantly negative tone to the participants' stories and accounts about their secondary school mathematics experiences. The apparent dislike and negativity around their recollections were associated with a range of dimensions of their mathematics classes including their success or failure, the personality and pedagogical practices of their teachers, and the mathematical content of their lessons and their perceived irrelevance.

#### *Mathematics Lesson Structure and Content*

In the data there was a remarkable consistency in the participants' descriptions of the structure of their mathematics lessons at secondary school regardless of the era in which they had attended school (i.e., participants aged between 17 and late 40's) or the nature of their school (e.g., single sex or co-educational, private or state). Almost without exception, the participants described in their interviews and journals, mathematics lessons that had many similarities to the one below recounted by Louise (in her journal):

*Our teacher was very loud and he would tell the class a whole pile of notes which were written on the blackboard and we would copy them down. Everything was explained clearly and to the point. Then he would fill up the board with examples, which we would madly scribble down as he explained so we could get it down before it was replaced by a whole lot more. Then it was textbook time - a page number and exercises were listed*

*on the board and we worked our way through them and what we didn't finish was homework.*

Louise's description highlighted textbooks as being a fundamental part of their mathematics learning at secondary school, a feature that was noted by 27 of the participants. A number perceived their mathematics learning as being characterised by working their way through the textbook and completing pages of exercises. The following extracts exemplify these views:

*Most of the mathematics I learnt I only recognised as 'maths' when I saw it in the textbook. (Felicity, Journal)*

*School mathematics is in textbooks. In school you just work your way through the textbook. (Marina, Journal)*

*I can't remember doing anything exciting. Like it was all textbook exercises and then, you know, ticks and crosses. It's the only thing I can really remember. (Jaimee, Interview 1.7)*

*Maths - it's all about textbooks isn't it? (Janine, Interview 1.3)*

Quite a few of the participants (18) reported that in their secondary mathematics classes most, if not all, of their work was from "the textbook", and for some even their notes were copied from the textbook. They also suggested that their homework was usually to complete the set exercises from the textbook, although Brad was not concerned about this because *the answers were always in the back and you could just copy them out!* (Brad, Interview 1.2).

Corresponding to the participants' recollections of textbooks was the importance of their mathematics exercise books. Of the 23 participants who mentioned their exercise books most had a set way to rule-up and set out their work and a few (5) had a two-book system where one was for notes and the other for exercises.

Allied to the fairly rigid and structured format to their lessons, some participants (7) also reported a classroom arrangement that was formal and based on rows of single desks or pairs of desks. For example, Joanna commented in her journal:

*I remember we all used to sit in single file and she used to walk up and down the rows while we had our textbooks out and did a set number of problems.*

Furthermore, eight of the participants also noted that they were streamed for their mathematics classes, and this particularly seemed to cause some problems for four participants (Marina, Myra, Neal and Karen) who felt that they were inappropriately placed in a high class and they struggled to keep up with the so called “intelligent ones” causing feelings of inadequacy, hopelessness, failure and frustration. In her journal, Nerolie noted her particularly adverse response to some of the issues raised above:

*My experiences of secondary school mathematics are more vivid and very negative. My recollection of the classroom is of rows of desks in which we sat according to our last test result - the highest at the back and the lowest at the front. I never got back past the first few seats! The teacher made life demeaning. ... My [secondary] school experience of mathematics left me with a bad taste in my mouth. (underlining in the original)*

The quotation from Nerolie also brings to the fore the issue of assessment and achievement that also featured prominently in the data related to the participants’ experiences of mathematics at secondary school. This issue forms the content of the next theme.

### *Assessment and Success*

The assessment practices reported by the participants concerning their secondary school mathematics education focused on tests and examinations. The following brief excerpt from an early interview (1.1) in response to a question about assessments at secondary school is typical of the views expressed in the data:

Louise: *We only did tests.*

Joanna: *Yeah!*

Mary: *Exams and assignments.*

Joanna: *I don’t remember assignments.*

Louise: *No, I don’t think we ever did assignments, I can’t remember. It’s a long time ago but always tests and exams.*

Joanna: *I wouldn't be able to remember if we did assignments for maths. I only remember tests and having exams.*

Interviewer: *So how often did you have tests?*

Mary: *At the end of every topic you'd been studying.*

Sally: *And so you were always working towards that test, and then you wouldn't touch the topic again until the exams at the end of the year.*

Although a number of participants (13) expressed views similar to Louise and Joanna above, quite a few others (11) mentioned doing an assignment for an assessment. Without exception, the assignments were statistical in nature and involved collecting some simple data and presenting it using graphs. One participant (Howard) reported doing a statistical investigation every year (from year 9 to 11) which involved counting the various colours of cars that passed the school gate.

The School Certificate examination seemed to be prominent in the participants' perceptions of their secondary mathematics education and was viewed as important. Grace sat School Certificate three times and failed every time, but she wrote; "*School Cert maths was a good qualification to have and that is why I kept taking it*" (Journal). A few participants recited their mark for the School Certificate examination and four reported hiring a tutor to help them pass. The following conversation (Interview 2.3) between three of the older participants (aged over 35) indicated their thoughts about the examination:

Mike: *I failed School C quite badly but I think if you gave me the test now I think I'd probably pass - just!*

Joanna: *I'd be quite interested to see if we could pass School C now.*

Louise: *Wash your mouth out!*

Joanna: *I didn't say do it, I said to see!*

Louise: *No, I must be honest. I still haven't lost the fear if I had to sit a School C maths paper and pass it. I don't think I have lost that fear.*

Success and achievement in their mathematics assessments seemed to be motivating for many of the participants, although most (27 of 31) reported finishing their formal mathematics education in failure (i.e., they failed in Year 12 so they stopped taking mathematics courses). Five of the participants commented that when they were successful in their mathematical assessments, they enjoyed the subject and they were more motivated to learn. Conversely, seven of the participants reported that lack of success led to a loss of enjoyment and feelings of frustration. Nerolie admitted in an interview (1.2) that she often cheated by copying from her friend so she could succeed in her assessment tasks!

The other key theme that emerged within the data related to achievement in their mathematical assessments at secondary school concerned their attribution for their success. According to many of the participants (11), if they succeeded at a certain level in their mathematics education then it was primarily because they had a good teacher:

*Mr. Williams' continuous patience and superb knowledge led to a B2 pass in School Cert. maths. (Marina, Journal)*

Also, a number of the participants (7) reported that the converse was the case - that a poor teacher was a prime factor in failure to achieve in formal assessment tasks.

*I had no chance of passing that year [12] because I had Mrs. Everingham and she was hopeless. (Murray, Journal)*

If the participants succeeded or otherwise, it appeared as if the teacher was perceived as a critical factor. Indeed, throughout the data related to their secondary school mathematics learning, the teacher was a significant, pervasive and enduring theme. This theme is presented below.

### *Mathematics Teachers*

When the participants were asked about their experiences of mathematics at school in the first round of interviews they often spoke about their mathematics teachers:

*My most vivid recollection of secondary school mathematics is probably the teachers that I had. (Joanna, Journal)*

Because their teachers, and in particular their secondary school teachers, seemed to be so salient in their recollections, two follow-up activities focused on this aspect (writing about them in their journal and drawing pictures of their teachers as a course activity). In all, the 31 participants mentioned 43 different secondary school mathematics teachers in the data collection activities.

Almost all of the teachers recalled by the participants fell into one of two categories - those perceived as being good and those perceived as being bad. Furthermore, many of the participants clearly identified the characteristics of those they perceived to be effective mathematics teachers and the ones they perceived to be inadequate. Some participants (5) said that they liked their mathematics classes when they liked the teacher and vice versa. The data contained comments on the teachers' personal attributes, pedagogical and classroom management practices, inter-personal skills and physical appearance.

Just over 70% of the secondary teachers recalled by the participants were judged inadequate, offensive or fearsome. Two of the extreme cases are illustrated below in the description Marina penned in her journal and in the quick but revealing sketch that Kathleen drew. These two examples are strongly negative, but they would not be uncommon in the data (see Appendix I for other pictures of mathematics teachers):

*In my personal experience my teacher became like a growling monster barring my way up the mountain [of learning mathematics]. He stood textbook in hand, his breath emitting from beneath fanged teeth and unbearable stench, his unapproachable stare sending me reeling back to the foggy bottom of the mountain to remain lost to understanding, at least for a while.*

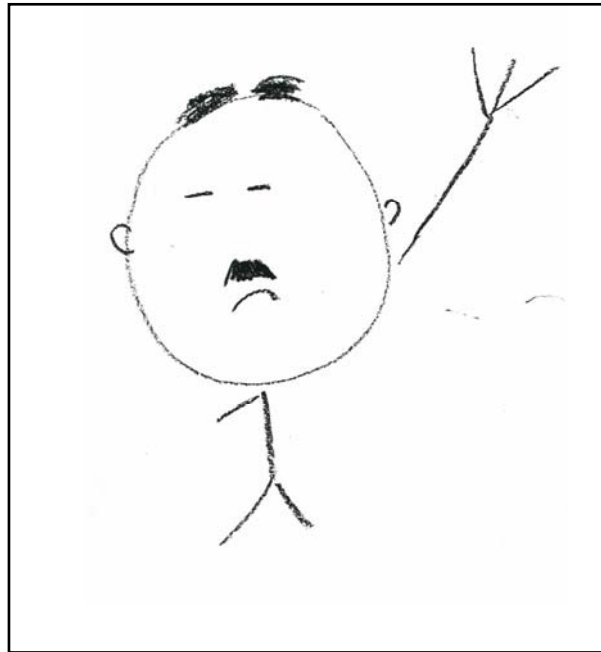


Figure 5.1: One participant's picture of her mathematics teacher.

The participants suggested that one set of problems they had with these teachers was their perceived inability to teach or communicate. A number of participants (8) described their secondary mathematics teachers as being very talented mathematicians with poor pedagogical and classroom management skills, as exemplified by Joanna who said:

*The one [teacher] I had in the fifth form was a brilliant man - I think he had a PhD! He did know what he was talking about, it was just we didn't have a clue. Also, he couldn't walk into the classroom and get the class to be quiet. We basically did what we wanted and I was a pretty conscientious student. (Interview 1.1)*

Poor classroom management was mentioned as a characteristic of 13 (of the 41) teachers that appeared in the data, including one story about a teacher who was locked in a cupboard by students. Other participants remembered spending many lessons in the corridor playing cards and reading magazines because they had been sent out of class, while one or two others told stories of being hit with a ruler when they made errors, didn't do homework, or forgot some required equipment.

The teachers that were disliked were noted by participants who perceived themselves as being unsuccessful in that particular class. In their descriptions of

these particular teachers, some participants (5) suggested that they showed favouritism to the brighter students and supported the pupils who were perceived as doing well. Two of the participants thought that this was because they related to those students well, but they couldn't empathize with the students who were less capable. Related to this, a few participants (6) thought that the teachers concerned taught the mathematics curriculum at a pace appropriate for the brighter students but too quickly for those who were struggling:

*My fifth and third form teachers were very clever and seemed to operate on a level beyond mortals like me. They moved too quickly through an equation and that may not have been intentional but that is the way it turned out. Because they had no experience of struggling with maths as a child themselves, they seemed to lack the ability to relate to those of us who were. Their kindred spirit seemed to be with the bright movers and shakers of the class. (Mike, Journal)*

The participants' perceptions of the secondary mathematics teachers they disliked often included detailed descriptions of their character traits and physical appearance. The participants chose to describe these teachers with adjectives including boring, impersonal, distant, humourless, never smiled, sarcastic, unenthusiastic, scary, unhelpful, dismissive, disorganised and often angry. Of these, the most common was 'sarcastic' which was mentioned for 12 of the disliked teachers, and similarly many (11) expressed a 'lack of relationship' as a critical factor. The memories of these teachers were often vivid as indicated by the rich descriptions they could give of their physical attributes and appearance. Marina's description at the start of this section focused on her mathematics teacher's "stinky breath" and below Beverley recalls her fourth form teacher:

*In fourth form I had Miss Turner [pseudonym]. She was middle aged and I remember that we didn't like her. She used to wear the same clothes to school all the time, and she used to have her hair gathered in a ponytail - top knot on the top of her head - and she used to have her dandruff. She was very buxom and she used to wear this purple sweater all the time. (Beverley, Interview 1.4)*



One participant also noted that her third form mathematics teacher was a metal-work teacher and she perceived that he had little interest in mathematics or their mathematical learning.

Finally, the participants who disliked their mathematics teachers reported feelings and emotions about their mathematical experiences at school. The following interview extract (Interview 1.2) exemplified the feelings of some of the participants:

Nerolie: *Maths was my nightmare; I shouldn't have done it really in the fifth form because he [the mathematics teacher] just made me feel so dumb. I was so dumb at it!*

Naomi: *Mine filled me with fear!*

Neal: *I was scared of mine, particularly in the fourth form. Boy if you ever made a mistake! ...*

Naomi: *And they were so sarcastic. ...*

Another participant remembered being “too scared to ask for help” while another said her teacher “gave her a fearful attitude”. While the higher proportion of the teachers recalled were disliked, there were a couple who seemed to be remembered in unemotional ways, and about 25% that were liked and respected. The descriptions of this positive group are outlined next.

Of the mathematics teachers that were remembered in a positive light, the most common characteristic was the personable way they related to the students. For example, Robyn described Mr Thorpe (pseudonym) in her journal as follows:

*He was definitely committed to the success of his students. An underlying reason as to why I liked Mr Thorpe was that to him we were more than maths students. He was interested in our lives beyond maths class and he took interest in our personal, academic, sporting and spiritual aspects of our lives.*

Kylie also noted the personal qualities of her favourite mathematics teacher, as well as some of her pedagogical strengths.

*Secondary school mathematics teachers varied as I had my favourite one in Form 5. She was a lovely person who had a positive attitude and a real*

*passion for her subject and in teaching. She was firm when students played up, but still approachable and encouraging when help was needed. She taught clearly and made sure everyone was OK with each topic before she moved on. She also got alongside students who needed that bit of extra help and made sure we had plenty of practice in exercises and applying what we had learnt. (Kylie, Journal)*

In describing the mathematics teachers they thought were good, the participants expressed qualities such as helpful, good explainer, humorous, knowledgeable, patient, committed and good classroom control. A few participants also considered that their teachers “made mathematics exciting” (3), and were “passionate about mathematics” (2), and this had a ‘rub-off’ effect on them when they were in their classes.

Almost all of the teachers that were mentioned in the data were either remembered in a positive light or a negative manner. The positively recalled mathematics teachers all seemed remarkably similar in the participants’ descriptions and the negative ones seemed to fit one of two particular stereotypes, and these are discussed further in the three mathematics teacher caricatures in the next chapter. The one exception to these descriptions was Mr Wisden whose description is partly reproduced below:

*Well my fifth form teacher maths teacher gave me a detention nearly every day, nearly every maths lesson. They were for not having my ruler or for just asking a question - if I asked someone else the question. But it’s kind of strange because he actually made me learn and I actually respect him now because he actually did make me learn. Like he sat me right up the front because he was actually going out with my maths teacher from the fourth form and they would discuss me and I was a bit of a naughty student in the fourth form. Well I wasn’t learning anything you know, I couldn’t do it and so I just developed an attitude and he sorted out my attitude in the fifth form really and I passed School Certificate. I wouldn’t have passed if it wasn’t for him. Like he would make me stand up and say “Marina, stand up and tell me the answers to the homework”, and so over the year I knew that I had to learn how to do it. I had to know how to do it*

*or I was, you know, he was going to humiliate me in front of the whole class! But he actually had the patience to teach me as well. That was the thing that really impressed me about him was that he didn't just focus on the bright kids, he actually focused on the kids who were having trouble and that were causing trouble and actually focused on them a lot of the lesson and made us learn. It was scary because I was the sort of person who didn't like speaking out in front of the whole class or anything so it was full-on, but he kind of made me do it. (Marina, Interview 1.8)*

Marina's description of Mr Wisden above seems to include features of both the teachers who were liked and respected, and those who were disliked and despised. Although the categories that emerged from descriptive data was reasonably clear-cut, this example highlighted that there are always exceptions, and indeed teachers are people and are therefore all different, as indeed are their students.

### **Experiences during their Tertiary Mathematics Education Course**

Part of the data collected focused on the participants' mathematical experiences during their initial tertiary course on the learning and teaching of mathematics. The aspects that related primarily to their beliefs and feelings about mathematics are largely addressed in the following section on the participants' affective views of mathematics and therefore will be largely ignored here. However, the themes outlined below were key factors in their affective responses through this time. Also, the participants spoke quite a bit about their developing understanding and knowledge of mathematical pedagogy (as you would expect), and although closely related, this data is considered outside the limits of the current study.

After coding the data related to the participants' experiences on the course, four themes seemed to emerge: (1) the class atmosphere; (2) the course lecturers; (3) features of the course; (4) key events and outcomes of the course. As each of these are addressed in turn below, the participants' views and perspectives are presented as they were identified in the data.

### *The Class Atmosphere*

Many of the participants (18) identified the class atmosphere as being a critical dimension of the course. They described the atmosphere as fun, relaxed, warm and inviting.

*The lectures, you know, we could just have easily have had half a dozen couches in that room and coffee in the corner and you'd just get up and make yourself a cup of coffee, you know! I could see that happening in our maths lectures very easily and that was a real difference [from their school experience]. (Warren, Interview 2.2)*

A fundamental aspect for many was that the atmosphere was quite different from their previous experiences of mathematics at school. Clearly part of this reflects the difference between a school and a tertiary culture, but there also seemed to be a sense of surprise that a course based on mathematics could be fun, enjoyable, relaxed and even inviting. This appeared to be a critical dimension in the participants' affective change of view as evidenced in the quantitative data (in Chapter 4).

*It was just the whole atmosphere. [The lecturers] were just so casual which just blew me away! For me that's WOW! Now my attitude is changing. ... (Nerolie, Interview 2.2)*

As indicated by Nerolie above, the course lecturers were seen as foundational to the atmosphere of the classes, and a number of participants commented on their qualities and practices.

### *The Course Lecturers*

The course was taught by two lecturers, one of whom was the researcher. They shared the teaching responsibilities evenly, although they rarely taught a lecture together, and the lectures were generally conducted in a workshop style. The data concerning the course lecturers centred around two main intimately linked dimensions - their practice and modelling, and their personal qualities or characteristics.

Just over half of the participants identified modelling as a positive feature of the course, suggesting that the lecturers enacted the theories, ideas, beliefs and practices they were teaching:

*I enjoyed the, how would you describe it, the way you have taught maths has come through. So we've done activities where [the lecturers] have modelled. Within maths we're learning by example how to teach maths through small groups and making sure we are all there or the way you phrase a question or the way you approach maths. (Mike, Interview 2.3)*

While many of their comments on modelling related to technical aspects of mathematical pedagogy, many of the participants (17) also noted other dimensions of the lecturers' practice including their enthusiasm and passion for the subject, and the way they related to the student teachers as mathematics learners. Marina identified and commented on the lecturers' enthusiasm for mathematics as a motivating factor in her own development:

*It has actually been the motivation that [the course lecturers'] excitement for maths has made me think, 'well there must be more to it than just what I've experienced in the past'. That's probably the most important thing I've learned. (Marina, Interview 2.2)*

Others thought that the lecturers had a passion for mathematics that extended to a zeal for them as mathematics learners and future mathematics teachers:

*I appreciated the passion of the lecturers for the subject and for us as teachers. That really stood out throughout the lectures. (Karen, Interview 2.6)*

*The lecturers - they really cared about us. I'd never experienced maths teachers like that before. Also, they were really passionate about the subject, which made it enjoyable. (Sharon, Interview 2.4)*

These comments are typical of a number of participants who noted the personable nature of the lecturers.

A relational pedagogical approach was foundational to the programme and the institution where the participants were enrolled, and many of them (24) commented on the lecturers' relational approach. They noted things like being approachable and available, being interested in the broader lives of the students,

being “connected”, and understanding and empathising with the students. The following quotations illustrate some of these points:

[The lecturers] *actually made an effort to get to know each of us and liked to talk to us in the corridors and I found that really good. It actually made me feel more confident. ... They taught from relationship and they like, got to know you and could help out. And I found that was probably the best thing about the course because it was so different from school because at school they didn't seem to bother with that. They didn't like to find out where you were at and so teaching from relationship, I think that was the thing that was really good stuff.* (Kylie, Interview 2.3)

*The lecturers were human with a sense of humour and big hearts.* (Jaimee, Interview 2.1)

And the following short extract from Interview 2.4:

Sharon: *The lecturers could communicate.*

Mary: *They connected with where we were at - and we were all over the place but they connected with each one of us in meaningful ways.*

Emma: *They were open and very interactive. Mostly they were very encouraging and we could ask them questions without fear.*

Mary: *Yeah. My teachers at school had lots of knowledge, but [the lecturers] had the knowledge but also the character and heart of a teacher.*

The comments the participants made regarding the relational style of the lecturers seemed to indicate a positive impact on their affective responses, and this was highlighted in the quantitative data (Chapter 4) as is furtherer outlined in the appropriate section later on. It should again be noted that one of the lecturers was also the researcher and interviewer, and although the participants were reassured that they could speak honestly, it is likely that their expressed views were tempered and only a few made critical comments. Nevertheless, their remarks were consistent with the other data and the course evaluations, and they resonate with the feelings and perceptions of the lecturers concerned. It did seem that for many, the lecturers were a critical a factor in the changes in their affective views of mathematics.

### *Features of the Course*

Apart from the lecturers, the participants identified some other important influential features of the course including the collaborative approach, the inclusion of practical examples and the extension of their thinking. In considering the data related to these three factors there was an underlying sense that these features were quite different from their school experiences of mathematics, and they were instrumental in facilitating their affective development throughout the course.

To work collaboratively in a mathematical context was reported as a new experience by a number (7) of the participants. These participants suggested that “working together” was important because they could understand the views and experiences of their colleagues while supporting one another as they considered critically their own mathematical views, beliefs and feelings:

*The group work for me was really good - being able to draw on one another and support each other.* (Emma, Interview 2.4)

*I enjoyed getting into groups and doing activities - learning together. I suppose that jig-sawing effect too of doing something and then joining up together and finding out what others thought and felt. Helping each other.* (Joanna, Interview 2.3)

They also indicated that the collaborative approach challenged their conceptions of mathematics as an isolated individual activity.

The incorporation of “hands-on” practical activities was also seen by some (12) as important as they reconsidered their views of mathematics. For example:

*It [mathematics] was a lot more practical than I had ever experienced. I did a lot of adding and subtracting but I had never seen algebra used in practical ways before.* (Helen, Interview 2.4)

*I think the practical things were the highlight for me. All those real-life things we did and then talked about in class.* (Nerolie, Interview 2.2)

Again, for many of these participants it appeared that seeing mathematics as practical was quite novel, particularly in an educational context. The excitement for a few of these participants was the new perspective it gave them on

mathematical pedagogy, particularly as they were facing their first school-based practicum.

Finally, six of the participants commented on how the course had “extended their thinking”. They seemed to be surprised at how much thinking and growth they had experienced in a course where they had enjoyed themselves, had fun and been involved in practical and collaborative activities:

*It [the course] has really been hard work. Boy have we worked! And think, [the lecturers] have really made us think. I couldn't sit down and say that this was a cruise class or a waste-of-time class. I've learned something every time and yet I've always had fun and loved coming. (Louise, Interview 2.3)*

*Yes, my mind really has been stretched, and through things like the field trip. Who would have thought it possible. I feel like I understand a lot more. (Anna, Interview 2.1)*

There was sense that their “mind stretching” and “extended thinking” was an on-going process and related to their grappling with their beliefs about mathematics as they had encountered new and different experiences of mathematics. The participants were able to identify some of the particular events in the course that facilitated their affective dissonance.

#### *Key Events and Outcomes of the Course*

Individual participants highlighted several different specific events as key aspects of the course. Four were mentioned by more than three people. The four events that received multiple support were the sessions where they specifically reviewed their own mathematical history, the first assessment assignment, the lectures/workshops on the Fibonacci Sequence and Golden Section, and the field trip. In particular, these activities seemed to prompt and support positive affective change for the participants.

Early in the course, the participants spent two sessions reviewing their mathematical experiences at school and trying to explicate their beliefs, attitudes and feelings from those experiences. One of the activities was the drawing of their



mathematics teacher and the resulting pictures have been used as data for this study. For a number of students in the course, these sessions were quite emotional and even painful as they relived unpleasant experiences from their school mathematics education (see previous section in this chapter). Despite the traumatic nature of these experiences for some, four of the participants identified them as being a crucial part of the course, three of whom particularly struggled with the sessions. For example:

*I loved the whole thing [the course] once we got past that dredging up all our past - I had to get counselling from my pastor you know! It was terrible going over all that again but I can see now that it was worthwhile - essential to me becoming a teacher and a whole person. (Naomi, Interview 2.6)*

*Drawing our previous maths teacher, that stands out for me. It wasn't so much me drawing but it was seeing all the Hitlers and monsters that everyone else had drawn. (Warren, Interview 2.2)*

For others, the ability to identify, record and discuss their feelings and attitudes to mathematics in the context of their school experiences was the start of rebuilding a new conception of mathematics. In relation to the course experiences outlined above, Marina penned the following in her journal:

*I'm starting to realise more what maths is. It's a whole new subject to me what I am learning now. Everything I've learned in the past is something else and now I am learning the real thing. That is the way I am looking at it!*

The second event identified in the data as being important was the first assessment task, which was an essay. In the essay the students in the course had to discuss how they could create mathematical experiences for children that would be exciting, interesting and educational. Ten of the participants said that for them, this was a strategic aspect of their development as teachers of mathematics.

## **Experiences on Practicum**

The participants undertook a school-based practicum experience in a primary (Year 0 to 6) or intermediate (Year 7 to 8) school classroom during the second

semester of the first year of their initial teacher education programme. The data for this section was collected through interviews that were conducted after they had returned to their lecture programme at their tertiary institution (i.e., phase three).

The data for this section is organised in three parts. The first part outlines the experiences of those who thought their mathematical encounters were good or positive and the second part those who felt otherwise. The final part addresses some common themes or issues that emerged throughout the data in relation to the participants' school-based practicums. The participants' affective responses to their practicum experiences is more fully presented in the following section.

#### *Positive Mathematical Experiences during their Practicum.*

Just over 40 percent of the participants returned from their school-based practicum and expressed positive reports of the mathematics they experienced. These participants were all in Year 0 to Year 5 classes (i.e., none were in a Year 6 to Year 8 class). These experiences were centred around the mathematics lessons they saw and taught with their placement classes. The participants concerned noted a number of features of these lessons including a “hands-on” approach, going outside, variety, a thematic approach and the use of mathematical games. Furthermore, some of these participants (6) also reported that the children in their classes seemed to be enthusiastic about mathematics and their mathematics lessons:

*I thought the kids were really into it. One girl had completed her whole maths project [about preparing for their class camp] in one week! ... I think it was because it was meaningful, they could see maths was needed for life because they obviously needed it for their camp. (Marina, Interview 3.7)*

The comment by Marina above was typical of the views of mathematics that these participants expressed.

For the participants who enjoyed their mathematical experiences during their practicum, mathematics was seen as being meaningful, connected, creative and involving problem-solving and “thinking strategies”. The views they expressed

about mathematics seemed to be closely related to the mathematics curriculum they encountered in the classroom with their associate teacher:

*The maths we did in class was real and meaningful in normal life. [The associate teacher] linked maths with other stuff we were doing ... (Janine, Interview 3.6)*

*The kids really had to think - problem-solving and all those thinking strategies in the numeracy project. Maths was a whole new experience for me, a completely new subject. I loved it. (Nerolie, Interview 3.4)*

What appeared to be the key for these participants was the consistency they perceived between the epistemological messages of their course on mathematics education and their practicum experiences.

The cumulative effect of their tertiary mathematics education course and their practicum was acknowledged by eight of the participants in their interviews. They suggested that their experiences on practicum reinforced their affective and cognitive learning from the course. Karen's practicum was in a year five class where she was given a small group of so-called slower children for mathematics. Her comments are linked together below to give a picture of her experiences:

*From the first day we did a pre-test for fractions, decimals and place value. From then I was straight into teaching a group of six children to cover the work of the pre-test. I was given the 'dumb' [sic] ones, and not all of them said it but some did say they were useless at maths and they had never done well in maths ever!*

*I took the group and taught them how I wanted to teach them. We started with cutting cakes up for fractions, games and also calculator work.*

*We did a lesson outside of the classroom working with water. We had a coke bottle that was like a fuel tank and a pilot who kept running out of petrol and didn't know why because he couldn't read how much petrol was in the tank and so their job was to put little fractions on his tank so he could tell. It was a problem-solving activity and the children had to find the fractions of the fuel tank using water. It was quite hands on and the children loved the work.*

*My group of children went up 20 to 56 marks from their original pre-test even though I taught them a different way from their normal maths lessons, so it certainly doesn't harm them.*

*They were more confident when we went out and would come back. They were confident in answering questions and the teacher was quite surprised because they were not usually very confident in maths.*

*I found the work we did on the course really useful in helping me teach maths. All my maths learning was textbook based and so I thought that maths was largely irrelevant and unrelated to anything - you just regurgitated stuff. The course really showed me how you could see maths differently and it really worked with the group of students I had. (Karen, Interview 3.5)*

While it seemed that Karen's associate teacher conducted a fairly traditional mathematics programme in her class, she was able to experiment with alternative pedagogical practices that were consistent with her tertiary mathematics education course. Because the teaching she employed seemed to be effective, the cumulative impact of the course and the practicum resulted in positive affective change for Karen. Unfortunately more than half of the participants did not have such a positive experience of mathematics during their practicum and their data is now presented.

#### *Negative Mathematical Experiences during their Practicum.*

For nearly 50 percent of the participants their experiences of mathematics during their school-based practicum was not considered good or positive. The majority of these participants had their practicum in a Year 5 to Year 8 class with most (11 of the 15) in Intermediate schools. One exception was Jaimee who was in a Year 1 class, and she reported:

*I was in a Year 1 class and I think we did no more than four 20-minute lessons in the four weeks I was there. When I first got there we had agriculture day coming up so everything had to revolve around that, but then we didn't really get into the maths again. But we did two addition lessons and two symmetry lessons. ... The kids did do some other maths*

*because when they were naughty they didn't write lines or anything, they had to do maths for punishment. (Jaimee, Interview 3.7)*

Indeed there are some concerns about Jaimee's experience, but it was not typical of those who reported a negative perception of their practicum mathematics.

As mentioned above, they were largely with older children, and the mathematics was described as content-focused, routine, worksheet or textbook-based, individualistic and lacking in variety. Most of the reports were of streamed classes which followed a 'pre-test, teaching, post-test' unit pattern, and an 'explanation, examples, worksheet or textbook' routine for the lessons:

*Every lesson was the same, except when we were having a test! The kids would arrive from their classes [because they were streamed] and [the teacher] would talk for about 15 to 20 minutes, then he'd do two or three examples on the board, ask if there was any questions, and there never was, and then exercises for the rest of the lesson. Finish the exercises for homework. (Kylie, Interview 3.2)*

Warren commented on routines after his practicum experiences:

*There was a structure to the maths class timetable because as soon as you changed anything the kids became really unsettled. I taught one lesson slightly differently from how the teacher always does it and boy the kids let me know! They like the routine of maths and you'd be crazy to change it. (Warren, Interview 3.4)*

While other participants in this group did not state it as clearly as Warren, there was a sense that mathematics was in fact routine, and learning mathematics was also best achieved through a fairly predictable lesson pattern.

Related to their experiences of mathematics and mathematics education being routine were their reports of the subject as being infallible and disconnected from 'real-life'. Again, some of the participants expressed a view that this was a legitimate perspective on mathematics:

*The maths classes were about learning their basic facts. ... The students spent all their time perfecting their maths skills and knowledge. ... We did one lesson on problem-solving but the kids didn't like it because they knew the basics is the really important stuff. (Darlene, Interview 3.1)*

Some of the participants (11 of the 15) in this group did comment on the affective responses of their students to the mathematics curriculum they experienced and the overwhelmingly common description was boring. While they could see and understand that many of the students in the mathematics classes were bored, they seemed to be resigned to the view that indeed mathematics is boring and this has to be accepted:

*The kids were mostly bored, probably because the lessons were always the same. But it is maths and you can't change the subject, can you?* (Helen, Interview 3.1)

An underlying theme of the data from this group was that mathematics is routine, dull, infallible and unchanging, and the experience they had on their tertiary mathematics education course were interesting, but largely irrelevant, at least in the school context. The affective responses of the participants to their practicum experiences are explored in greater detail in the following section, and in chapter six these themes are again presented through narrative case studies of some individuals.

#### *Common Themes in the Practicum Experiences*

Throughout the data in this section there were three common themes that emerged regardless of whether they perceived their experiences as being good or otherwise. Firstly, there were a number of participants who felt that their mathematical knowledge was inadequate. Secondly, the emphasis on number in the curriculum was evident in the data and finally, many emphasised the importance of “the basics” (which is outlined in more detail in a later section on this theme).

A number of the participants (14) returned from their school-based practicum and felt they wanted and needed to improve their mathematical knowledge. This was particularly the case for those who were initially anxious about mathematics and their practicum was in a class of older children:

*The practicum really did it for me because straight away I was with an intermediate age group and I thought ‘oh no!’. You know, my maths isn’t*

*even up to that level and sometimes it wasn't actually.* (Nerolie, Interview 3.4)

*I think the other thing I've realised ... is that we've still got a big hole in our maths knowledge.* (Joanna, Interview 3.2)

Another participant expressed a desire not to know more mathematics, but rather to have a greater depth of understanding:

*I was challenged because often I know how to do something but I don't understand the concept behind it. For example, I can do things with fractions, but I've got no idea about why you do it and what the concept is all about. We were never taught that sort of stuff at school.* (Karen, Interview 3.5)

It seems that for this group of participants their classroom teaching experience with children alerted them to the shortcomings in their own mathematical knowledge and understanding, particularly as they are undertaking a career in teaching.

As well as commenting on their own mathematical competence, many participants also noted the strong emphasis on number in the classroom curriculum. Of the 31 participants who undertook the practicum, 28 commented on the mathematical topics of their lessons and 23 reported primarily teaching numeracy. For example:

*I had to teach numeracy [place value] to these new entrants ...* (Renee, Interview 3.4)

*I was at [a local] school with Year 3 and when I got there they were beginning to learn family of facts;  $2+3=5$ ,  $3+2=5$ , etc.* (Sally, Interview 3.6)

*I had a Year 7 class and we did long division for three weeks and then we did long multiplication again.* (Kay, Interview 3.1)

Many of these participants (14) seemed to think that this was a good thing because number skills and understanding are the fundamental and most important part of mathematics. This is illustrated in the short interview extract below:

*We did number stuff for the whole time [with a Year 4 class] but that's OK because that's what maths is about really until you get to High School.* (Belinda, Interview 3.2)

*Yeah, we did all number, but that is all you really need to learn because you use it in real life. (Paul, Interview 3.2)*

Related to the emphasis on number was the perception that “the basics” were of primary importance, however this will be addressed in a following section.

### **The Participants’ Affective Responses to Mathematics**

During each data collection phase of the study, the participants discussed and commented on their affective views towards mathematics and mathematics education. At times they overtly addressed and commented directly on their affective views, and at other times they revealed their beliefs, attitudes and feelings indirectly through recounting their experiences in various ways.

In the literature review (Chapter 2) the affective domain was presented in a holistic way, incorporating beliefs, values, attitudes and feelings. However, in presenting the data concerning the affective domain it has been necessary to structure it in some way, and therefore the following sections are based on its component dimensions. Also, after coding the data, the category of ‘values’ seemed rather sparse and so it has been left out of the following sections. This is not to say that values were not permeating all the discussions and views, as indeed all research events are value-laden, but rather in this categorisation of the data the concept of values did not emerge. The affective domain is complex and each of its components variously defined, and so the categorisation of the data in itself is not seen as overly critical, and others may have coded various aspects differently, but what is central is the overall picture of the participants’ affective development which, in this case, included beliefs, attitudes and feelings.

The data is presented in three sections starting with beliefs about mathematics, then attitudes towards mathematics, and finally feelings about mathematics. In each section the three phases of the study are addressed to try and show the changes in participants’ affective views as the year-long study progressed.



## **Beliefs About Mathematics**

In exploring their beliefs about mathematics the participants expressed a range of views concerning the content of the discipline, its uses and epistemological factors, and its nature. The data were gathered through a range of methods including the interviews, participant journals and the metaphors they wrote during their mathematics education course. The data in this section will be presented in three parts in line with the three phases of data collection, with the initial focus being on the participants' views at the start of the study.

### *The Participants' Initial Beliefs About Mathematics (Phase One)*

When discussing or exploring the nature of mathematics, many of the participants initially mentioned aspects that make up the content of mathematics. The most popular description was “number” which was mentioned by 19 of the participants. Typical comments included:

*Maths is the study of numbers.* (Karen, Journal)

*When I think of maths I think of numbers ...* (Jaimee, Interview 1.7)

Often the participants reported other mathematical topics as well, including the following that were mentioned more than once: equations (8 participants), formulae (8), patterns (6), measurement (4), arithmetic, specifically “addition, subtraction, division and multiplication” (3), shapes (3) and symbols (2). Of the participants who mentioned “equations” it was evident that they were referring to arithmetical-type equations rather than algebraic equations, consistent with the general theme of the data that mathematics is primarily about number and operations with numbers. Some of the participants mentioned algebra and trigonometry as facets of mathematics that they did not enjoy at school, but no one listed these areas in the current context.

Alongside the views the participants expressed about the content of the discipline, they also disclosed beliefs about the epistemology of mathematics. Without exception, those (17) who commented on this topic all revealed an absolutist perspective of mathematics and mathematical ability. Primarily this was expressed through the view that mathematics is characterised by absolute, clear-cut truth that has a rigid, hierarchical structure. Seven participants suggested that in

mathematics there is always a correct answer and you know when you haven't obtained it. The following short extract from an early interview (Interview 1.2) illustrates this point:

Nerolie: *Yeah, it's either right or wrong. It's not like [the lecturer] was saying yesterday about how you get there.*

Neal: *Well there's not many ways to add one and one though is there?*

Nerolie: *No, in maths there is only one way.*

Neal: *That's what is so good about it!*

Furthermore, mathematics was viewed as a hierarchical subject by some (5) and if you did not understand it at one level then you would be unable to grasp it at any subsequent levels:

*For me, maths is like if you miss a step then basically you've lost a whole lot because you just missed that little piece of information, and then you're lost from then on. (Jaimee, Interview 1.7)*

*Maths is like building blocks - each bit builds on top of the last bit. (Renee, Interview 1.5)*

Another way (8) this was expressed was in comments about mathematical ability being innate, as illustrated below:

*For some people, their brains just work that way and that's the way their brain works. But for others, their brain doesn't work that way - they haven't got a maths brain - and so if you try and develop their brain in that way you won't get anywhere. (Caitlin, Interview 1.5)*

*I believe the ability to think mathematically is innate. (Felicity, Journal)*

The over-riding theme of this dimension of the data was that mathematical ability is predetermined and fixed.

A small group of the participants (5) made comments that indicated a utilitarian perspective of mathematics. For these people, mathematics had a range of skills that were useful and necessary for life, and they often referred to these as "the basics" (which is discussed in a later section). In her journal, Joanna penned the following comment:

*In our vast and steadily increasing world, mathematics is vital to survive. To cope financially, we must have a good knowledge of money and*

*percentages. If we want to keep up with the busy pace of our modern lifestyle, we need to be able to read the time and plan ahead. Depending upon the career each of us chooses, different mathematical abilities will be needed to cope and to succeed in this world.*

Also, when Tina wrote a simile for mathematics she highlighted its utilitarian nature:

*For me maths is like a map. It is not necessary to have but it helps you to understand and make sense of different areas in life. You will get where you are going faster with a map and likewise with maths. Some maths is more complicated than others.*

There were also another group of six participants who saw mathematics as being useful and necessary, but unpleasant and to be avoided if possible. Again, this was illustrated in some of the simple metaphors written by the participants:

*For me maths is like having to kiss your grandmother! It is not nice at the time, but it is necessary and it has advantageous results, so forget about her moustache and look forward to the presents. (Neal)*

*For me maths is like an injection - I run a mile! I know it is part of life, a necessary medicine to take and as I have aged I have developed strategies to cope. Blink my eyes and get it over and done with and move on. (Louise)*

The similes reported above exemplify the perspective of mathematics as “a necessary evil”, thus featuring the somewhat contradictory mix of a utilitarian epistemology and negative disposition.

A negative disposition towards mathematics was a theme that also emerged in many of the participants’ (16) views on the nature of mathematics. Key ideas that emanated from the data were that mathematics is difficult, confusing, irrelevant and useless. The notion that mathematics is “hard” was mentioned by nine participants in various forums (e.g., interviews, journals and metaphors) and two of these are quoted below:

*Mathematics is hard and I don’t know how to do it! It is a hard subject. (Murray, Interview 1.3)*

*For me maths is like a swinging trapeze without a safety net - dangerous, unnecessary and for me, pretty much impossible! (Sally, Metaphor).*

*For me maths is like a walk in a deep, dark bush uphill. Hard work, tiring, each footstep unsure, well avoided. So like maths and a walk in the bush, it should be taken in small doses or avoided at all costs. Too hard, too big, too tired, too long, too much, TOO MUCH! (Emma, Metaphor)*

Related to the perception that mathematics is difficult was a view that saw it as “mysterious”, “puzzling” and “confusing”. This was reported by six participants, and it was often connected with the notion that “only people with a mathematical brain will understand it” (Felicity, Journal). Grace struggled with mathematics at school and she revealed that for her, the confusing nature of mathematics left her feeling frustrated and inadequate:

*For me maths is like a hurricane twisting and turning, wrapping me up in confusing, cryptic, mysterious equations drawing my thoughts to a point of destruction then spitting me out feeling that I haven't mastered the art of maths. (Grace, Metaphor)*

The feelings of the participants towards mathematics were explored more fully in the previous section devoted to that dimension of the data, but Grace's metaphor above shows the connection she made between her abstruse view on the nature of mathematics and her personal sensibilities.

A further perception of mathematics was that it was “irrelevant” and “useless”. This view arose for twelve of the participants and the following quotations typify their responses:

*Why learn pages of formula and how to find the area of a parabola or other irrelevant shapes because it is hard to comprehend when or where you will use this in your life-time (unless you want to be a maths teacher!!). (Brad, Journal)*

*I often quizzed my teachers by asking, “OK, I'm going to use this when?”, and that was part of my attitude. But I've also heard lots of people say that sixth and seventh form maths is stuff you'll never use, you just learn to do it. (Janine, Interview 1.3)*

*Maths is totally irrelevant. You know there is just no need for it.* (Marina, Interview 1.8)

However, the views of these participants were balanced by others who saw mathematics as useful and necessary for life as reported previously.

Finally, nine of the participants reported beliefs in the initial phase of the study that related to doing and learning mathematics. In short, their perceptions were that mathematics is a form of mental exercise that requires cognitive effort, practice and memorisation, and that it can be known and done but rarely understood.

*Maths is about brainwork. You know - remembering stuff. Lots of memorising and remembering.* (Grace, Interview 1.1)

*Maths is important because it exercises and stretches the mind.* (Warren, Interview 1.5)

*Maths is mental gymnastics - like a workout for the mind.* (Beverley, Journal)

Of the nine participants who shared views similar to those quoted above, seven also mentioned that mathematics was largely irrelevant, and its only value was to “train the brain”. In his journal, Mike mused over these views while he was also wrestling with new perspectives that were being introduced in his tertiary programme (about integrating their personal worldview and their studies):

*I think it [mathematics] is good in that it broadens the mind into areas that you'd never understand. There's an unknown in maths, there's the infinite. Maths is a good way of making us aware of it I guess, so that whole broadness of life and thinking across all of life is covered. Maths is a good way of seeing that breadth and depth of life. It is the total unknown.*

Mike's comment seems to highlight the mystery of mathematics and its role in developing the brain while simultaneously valuing the dimension it brings to a fuller understanding of life (i.e., the infinite).

During their tertiary course in the teaching and learning of mathematics, the participants were challenged to consider their beliefs about mathematics, and the following section details the data gathered in the second and third phases of the study.

*The Participants' Beliefs about Mathematics after their Initial Tertiary Course in Mathematics Education (Phase Two)*

In interviews after the completion of their tertiary course in the teaching of mathematics the participants again reported their beliefs about mathematics. There were some significant changes in their views and these are outlined below, using similar themes to the ones used in the previous section. The most common theme in the data concerning their initial beliefs was the content of mathematics, but immediately after their mathematical pedagogy course they spoke more about beliefs concerning the nature and purposes of mathematics. However, it was probably not unexpected that the participants were able to report views about mathematics that were deeper and more articulate after completing a tertiary course in the teaching and learning of mathematics, and this was evident in the data presented below.

During the second phase of data collection, the participants did again highlight aspects of the content of mathematics, although not in the same way, or to the same extent as they had previously. In this phase they mentioned the following mathematical topics: patterns (5), number (4), problem-solving (3), equations (2) and measurement (2).

*Because maths is the study of patterns and number relationships, and God created these, then mathematics is based on observation of what God has made and set in motion - about creation and the universe. (Felicity, Interview 2.1)*

Felicity's comment above is indicative of the different ways the participants concerned reported their views about the content of mathematics. While the comment is about patterns and number, they are discussed in a more integrated, philosophical manner indicating deeper thought about the nature of mathematics.

The participants also commented reflectively about the epistemology and philosophy of mathematics. In general, the data revealed a view of mathematics as a human activity, that is ubiquitous and that "helps us make sense of the world

around us”. These views seem to be reflective of the views of the course lecturers and the course rationale (as stated in the official course outline).

Eight of the participants shared a belief that mathematics was fundamental in making sense of the world in which we live, as illustrated by Karen:

*Mathematics gives you the skills and knowledge to figure out the world around us and how to cope and work in it. (Interview 2.6)*

Here she has also highlighted a utilitarian perspective of mathematics, a view that also featured in some of the participants’ beliefs prior to commencing their tertiary programme. Others (6) likewise noted a functional view of mathematics, including Emma who said:

*Maths is an important part of life - an essential tool, and I’ve only made that connection in the last few months. I mean, my schooling - maths was maths. I didn’t consider that maths was anything else other than mental gymnastics. But now I have learned, and my children are learning, that maths is an important part of life. (Interview 2.4)*

When these particular participants were asked to illustrate their utilitarian view, they gave examples related to estimating distances while driving, estimating and measuring quantities while preparing food, and reading the time. Four of the participants were also quick to add that the mathematics they learned at school did little to help them with the mathematics they used in everyday life (as exemplified by Emma’s comment above).

Also during phase two, the data collected contained a number of adjectives describing the nature of mathematics. Apart from “logical” (which was employed three times), no single adjective was used by more than one participant, but the range included: “creative”, “imaginative”, “useful”, “applicable”, “scientific”, “structured”, “interesting”, “irrelevant” and “boring”. It was Samantha who thought that mathematics was boring, and she felt an inherent tension in holding this view as she expressed in her interview:

*I know this isn’t the PC thing to say after our course, but from my school experiences I don’t want to teach maths because I can’t see the relevance of it - it is just boring! I know it has to be covered but I don’t want to be the one to inflict that on the students. I know that I will struggle to*

*genuinely feel interested in maths and portray that to students.* (Interview 2.6)

While Samantha's comment is not reflective of the participants in general during phase two, it does highlight the relatively limited impact of the tertiary course compared to her experiences as a school student. Nevertheless, the data gathered in phase two indicates a qualitative difference from the first phase in the participants' beliefs about mathematics, which is consistent with the quantitative data presented in the previous chapter. In other words, the tertiary course seemed to make a difference in positive terms for most students. Further qualitative data concerning the participants' beliefs about mathematics was collected during the third and final phase.

#### *The Participants' Beliefs about Mathematics after their School-based Practicum (Phase Three)*

After their practicum, the participants were again interviewed, and some of the data focused on the participants' beliefs about mathematics. In general, the participants were less forthcoming in sharing their beliefs about mathematics during this phase as they seemed more concerned with pragmatic teaching issues. The content of mathematics was once again the most prominent theme and the participants discussed it in relatively simple ways. Two examples were:

*Maths is about understanding numbers and how to multiply, divide, subtract and add. You know, how you can use these to change numbers around.* (Sally, Interview 3.6)

*It [mathematics] is about numbers, measurement, counting and stuff, time, percentages, graphs - yer, all the strands in the curriculum document.* (Robyn, Interview 3.5)

Two of the participants suggested that mathematics was the material contained in the curriculum document (*Mathematics in the New Zealand Curriculum*). Discrete aspects of the discipline mentioned by others included: numbers (5), arithmetic (4), counting (4), measurement (4) and graphs (2).

While several beliefs about mathematics were expressed in the third phase, only two were mentioned by more than one participant. The first was an absolutist



epistemological view of mathematics and mathematical ability that was reported by four participants. Their views included the perspective that mathematics is either right or wrong, and that people are either good or bad at mathematics, as illustrated below:

*I hate to say it, but I think maths has to be exact. I mean, it is either correct or it's wrong. You can't get away from it, and as harsh as it may sound, some kids can get it right and some just don't get it!* (Bronwyn, Interview 3.6)

Four participants also described mathematics as dull or uninteresting after their practicum experience. In each of these cases the participants concerned seemed to link their view of mathematics to the way it was presented by their associate teachers during their school placement. Jaimee's comment below followed her school-based practicum in a year one classroom (six-year old children):

*Maths was different from other subjects. With their other subjects there was always a picture to draw or colour but in maths it was always "put your coloured pencils away", even with symmetry. What is it about maths that makes it so colourless and dry?* (Interview 3.7)

### *Summary*

Overall, the participants' beliefs about mathematics and mathematics learning reported in the qualitative data were consistent with the patterns identified in the quantitative data. Initially, they predominantly viewed mathematics as absolute, innate, irrelevant, difficult and boring, and it was mostly about numbers. After they completed their tertiary course in the learning and teaching of mathematics, most of them regarded mathematics as a human activity, ubiquitous and useful, and they seemed more able to articulate their beliefs. However, after their school-based practicum many of the participants were not overly interested in discussing their mathematical beliefs, as they were predominantly interested in practical pedagogical concerns. Their views at this point seemed quite shallow and related to the content of mathematics.

## **Attitude Towards Mathematics**

As the literature review showed, attitudes are often viewed as a fairly stable positive or negative response to something - in this case, mathematics. It was also mentioned that attitudes, emotions, beliefs and values were complexly inter-related and often the terms are used interchangeably. This was evident in the data, and indeed many of the reasons given for certain attitudes have already been discussed in the previous sections on beliefs and in particular feelings. Therefore, in this brief section, those reasons will not be reiterated, but rather some of the data particularly referring to attitudes will be presented.

When describing their experiences of mathematics at school the overwhelming majority of those who discussed their attitude (14 of the 17 who mentioned attitude) said it was “bad” or “negative”. For example:

*I confess I have a dismissive and negative attitude towards maths that was developed from insensitive and boring teachers during my secondary school years. (Marina, Journal)*

One participant talked about having a good attitude to mathematics and another said her attitude was “neither good or bad”. Yet another participant commented on her attitude through her secondary schooling:

*When I think of secondary school maths I have a mixture of different memories - sometimes my attitude was good and sometimes bad. It seemed to get worse the further I went through my high school maths when I had to do algebra and other equally confusing topics. (Myra, Journal)*

As with Marina and Myra above, all of the participants who talked about their attitude did so with reference to their secondary schooling only. While the striking negativity of the data related to their mathematical experiences at school is consistent with the quantitative data presented in Chapter Four, it also may be true that for many of the participants, having a sympathetic forum to present and discuss their negative experiences of mathematics enabled them to share freely. These participants were passionate about their feelings and attitudes and tended to give full and rich descriptions, whereas those with a positive attitude tended to be less committed to their views and therefore, less verbose (Researcher’s Journal).

Fifteen of the participants reported on their attitude after their tertiary course on the learning and teaching of mathematics. Of those fifteen, only one said that their attitude to mathematics was “still negative”, and nine specifically talked of how their attitude was changing or had changed. Nerolie felt that it was important that she had begun to change her attitude for the sake of the children she was going to teach:

*It's like it's so important for me to work on my maths attitude because if I don't so many people [students in her future classes] are going to end up where I was before I started this course. They are going to end up with a bad attitude towards maths because I had a bad attitude towards maths. So I think that was the big difference for me. (Nerolie, Interview 2.2)*

Like Nerolie, other participants who reported a positive change in their attitude to mathematics were pleased and excited about their new perspective, but they suggested that it wasn't an easy or completed process. Michelle commented:

*I guess I still have a little bit of a hang-up about maths. I had a bit of a hang-up every morning that I had to overcome each day [they had mathematics education lectures] so it's a strange thing but slowly I am enjoying it. It's still something I have to get past, but yeah, slowly I am becoming more positive. (Michelle, Interview 2.1)*

This process continued for some of the participants during their practicum.

As with the other aspects of the data, the participants were less willing or able to discuss their own attitude to mathematics after their school-based practicum. The few (6) who reported directly about their mathematical attitude were equally divided between being positive, neutral and negative. However, a number (12) reported on their perceptions of the children's attitude to mathematics in the classes they taught and of these, 67% felt the children were negative. Finally, a few of the participants commented in a thoughtful way about the struggle they were continuing to experience as they sought to change their attitude towards mathematics:

*I think you have to be careful not to let the old habitual attitude creep back in because I found that sometimes you hear maths and you think 'aaagh!'. Then you realise that maths isn't too bad, but it takes time to change the attitude and constantly remind yourself that it is OK. The [old negative]*

*attitude is still there and I have to keep overcoming that attitude and that it can be fun and that you can do it. (Marina, Interview 3.7)*

Marina's story is presented in more detail in Chapter Six, but her comment above highlights the difficult and on-going process of attitudinal change that some of the participants experienced throughout their first year of teacher education.

## **Feelings About Mathematics**

Throughout the study, the participants expressed their feelings about mathematics and their mathematical experiences. While some of these feelings have been captured through the written data collection methods and the interview transcripts, it would be fair to say that the emotional dimension is hard to capture when real, rich life experiences are reduced to words and pictures. At times during the interviews and the class activities, tears were shed and laughter was heard, but this dimension is unfortunately largely absent in the data. Nevertheless, the data revealed some strong emotions about mathematics, particularly when the participants were recalling their school experiences.

The data concerning the participants' feelings will be presented in three sections corresponding to the three phases of the study, beginning with the first phase concerning their experiences as a school student.

### *The Participants' Initial Feelings About Mathematics (Phase One)*

For most of the participants, memories of their school mathematical experiences were emotional and often related to two key factors, namely their teachers and their perceived success or failure. Many of the participants (24) conveyed feelings of enjoyment associated with their mathematics education at school. However, most (17) of these were specifically related to their primary schooling:

*I really enjoyed maths at primary school. (Myra, Interview 1.3)*

*I really liked maths, in primary school especially. (Renee, Interview 1.5)*

Often their feelings about mathematics from their school experiences were related to their success in learning and understanding the subject. This point was noted by nine of the participants who made comments such as:

*I did understand the basics of mathematics at this stage [form 2] and it was my favourite and most enjoyable subject, and I did well. (Brad, Journal)*

*Yeah, I think I enjoyed it once I started understanding what maths was about and algebra and things. Once I started understanding it I really enjoyed it - it just grew on me. (Helen, Interview 1.3)*

Another to remember an emotional response to success in learning mathematics at school was Marina who expressed joy, excitement and surprise. The transcript extract below does not do justice to the animation and feeling she displayed as she shared the experience in the interview, but it is reproduced nevertheless:

*When I could actually do it I actually got quite excited, and when you do get that feeling like 'oh, I can do it', and then you want to do more. It was exciting! ...I mean, I passed fifth form maths which to me was, it was a miracle, you know - I couldn't believe it - I was just so rapt you know - stoked! I actually passed School C maths! Another cool thing was I didn't have to sit it again next year. So cool. (Marina, Interview 1.8)*

During the part of the interview recorded above there was a sense of genuine surprise and delight in Marina's tone that she had actually passed her mathematics examination - a task that she had thought was seemingly difficult or impossible. Later in her interview, she attributed much of her success to her teacher - a man she didn't really liked but she did respect. Other participants however, did like their mathematics teachers and they suggested that these teachers made mathematics enjoyable for them.

The importance of teachers in the participants' affective responses to mathematics was discussed earlier, but it is noteworthy that quite a few (7) thought that their teachers were critical for their enjoyment of mathematics:

*The year I loved maths and found it interesting was when I had fun learning. Mr. Nathan [pseudonym] was an awesome teacher who really encouraged us and I liked maths and going to maths class. (Sally, Interview 1.1)*

*In primary school one particular teacher stands out in my memory for having made mathematics enjoyable. (Karen, Journal)*

For some (3), this was connected to their perception of success in learning mathematics, because they saw their teacher as the critical factor in their mathematical learning, for example:

*I used to like it better when I had a good teacher. A better teacher meant better grades in mathematics.* (Renee, Interview 1.5)

While there were a few participants who could recall happy memories of mathematics from their school experiences (as shown above), the majority were associated with negative feelings that ranged from dislike to hatred, dread, fear and stupidity. Of the 31 participants, 30 recounted at least one example of when they felt negatively about mathematics during their schooling. In all, 113 instances were identified in the data related to their school mathematics experiences where the feelings expressed were disapproving or negative. The most common types of feelings included were unenjoyment and dislike (23), boredom (12), hatred and dread (10), confusion (8), frustration and helplessness (8), incompetence and inadequacy (23), and anxiety and fear (18), and these are now briefly presented in turn.

As indicated above, many of the participants did not enjoy mathematics during their schooling and their dislike for the subject was accompanied by feelings of boredom and disinterest. A high percentage (65%) of the participants expressed feelings of general dislike for mathematics during this phase and the following comments exemplify their views:

*I have never really liked maths since I was about nine.* (Kylie, Journal)

*For me maths is like being around someone who has stinky breath. It is smelly and not at all pleasant to be around.* (Angela, Metaphor)

*I wasn't a maths person. I never really enjoyed it.* (Felicity, Interview 1.3)

*I don't love maths - I can do it, but I don't like it.* (Karen, Interview 1.6)

Often during the group interviews, others would nod or express some sort of agreement or empathy with those who were sharing their feelings of dislike. Furthermore, for a few participants (6) their feelings were much stronger than dislike, and they disclosed emotions of hatred and dread.

The participants who expressed hatred about mathematics could clearly articulate some of the experiences where these feelings developed and the associated feelings:

*I could do maths quite easily although it was boring and repetitive. But then we got to algebra! I hated it and then I basically gave up. I got through it all but I really hated it. (Aliesha, Interview 1.7)*

*Maths is a nightmare. (Nerolie, Journal)*

*For me maths is like dancing lessons - you dread it and dread it and when you get there it is as bad as you thought it would be. (Danielle, Metaphor)*

During one of the group interviews, two of the participants were sobbing as they relived some of the emotions they recalled from their school mathematics experiences. Another participant was so upset by her memories of mathematics at school that she had to get some counselling so she could cope and move on. She noted in her journal:

*I haven't been enjoying delving into my memories about learning maths at school - it has dragged up a lot of hatred and insecurity. I want to be positive about maths but the feelings are so strong. I have seen the Pastor at church to get some help to cope because you [the lecturer] have made us dig around into stuff I had buried a long time ago and now it has re-surfaced. Will I be able to teach maths? I hate feeling this way. (Naomi, Journal)*

Naomi revealed a range of emotions in response to her school mathematics experiences (and the reliving of those experiences) including a sense of confusion. However, she was not alone in her feelings of bewilderment and perplexity as six others disclosed similar feelings:

*For me maths is like landing in a foreign country. It is confusing and there is a build up of pressure as I flounder around trying to get from A to B. I'm interested in everything but I just don't get it. (Nerolie, Metaphor)*

*Maths - irrelevant, abstract, confusing, brain-strain. (Sharon, Journal)*

Allied to feelings of confusion, a number (7) also expressed frustration and helplessness associated with their memories of mathematics at school.

Many (18) of the participants expressed their feelings of incompetence and inadequacy in relation to their experiences of mathematics as a school student:

*I did School Certificate [mathematics] twice and it made me feel stupid - I couldn't even pass and I was way below average. (Dave, Journal)*

*I just hated maths - it was a humiliating, horrible experience compared to all my other classes. (Caitlin, Interview 1.5)*

*In maths I felt like an imbecile. (Louise, Journal)*

*I remember doing maths in the fourth form. After doing some test the teacher told me I was not even up to a third form level. I felt so dumb - not even up to the third form standard. I felt so rotten about that, I mean I was just crying, but what could I do because I know I was stink at maths. (Grace, Interview 1.1)*

Almost all of these were associated with their secondary schooling and commonly with failure also, and they described themselves as feeling dumb, stupid, belittled, embarrassed, humiliated, inadequate, demeaned and a failure. For a number (8) these feelings were often exacerbated by public embarrassment after failing to perform some task in front of the class, and the teacher was often perceived as culpable in these events. The examples below are from participants aged between 18 and 40, indicating for some that the memories are deep and long lasting:

*I remember in form three having to stand up in class and answer some irrelevant question - I thought "ooooh, cringe!" I don't know if I knew the answer but when Mr Swanson [pseudonym] dissed [rebuked] me I just shrivelled up inside. After that day I tried to never answer a question again. (Sally, Interview 1.1)*

*One part of maths lessons I hated was having other students mark my tests and Mrs Black always did it - she was a cow! Because of this everyone in the class knew I was an idiot and couldn't do maths. I was dumb and because of her everybody knew it. (Emma, Journal)*

These feelings seemed to lead to stronger emotions for some of the participants (9) who described sensibilities of fear, anxiety and terror.

When facing public humiliation in front of their peers, some (5) reported feeling panicked:



*One [teacher] had the unfortunate habit of asking people in the class for their answer, and for those of us who struggled that was pretty scary stuff. We felt like we were there waiting for the next opportunity to make an idiot of ourselves. (Mike, Journal)*

When asked if this occurred in other subject classes, they reported that it was only peculiar to mathematics. Apart from panic, participants reported feeling scared, terror, fearful and anxious, and perhaps the two examples below capture some of their emotions. The first is a metaphor penned by Kaye (aged 40), and a picture drawn by Jaimee (aged 19):

*For me maths is like a necessary evil. You know it is a part of your life, but somehow it always seems to feel like a deep, dark secret waiting to catch you out. Like a lion, watching to devour you and spit out your bones. (Kaye, Metaphor)*



Figure 5.2: Jaimee's drawing of her mathematics teacher.

The feelings outlined in this section are those the participants expressed at the start of the study and they were associated with their schooling. The second phase of data collection revealed more of the participants' emotions towards mathematics, and in particular the feelings they had after they had completed their initial tertiary course in the learning and teaching of mathematics.

*The Participants' Feelings about Mathematics after their Initial Tertiary Course in Mathematics Education (Phase Two)*

Of interest at this stage were the participants' feelings about mathematics after their affective responses to mathematics had been overtly addressed in their mathematics education course, and whether their reported emotions had changed since the initial phase of data gathering. Broadly speaking, the participants' feelings about mathematics seemed to be much more positive and many of the negative emotions were conspicuously absent in the data.

The predominant feeling expressed by quite a few (12) participants was confidence:

*There are many questions I still have but I feel like my confidence has definitely gone up heaps. (Marina, Interview 2.2)*

The confidence they expressed was related to a broader conception of mathematics that wasn't limited to their school memories (that were reported in an earlier section) but was rooted in the course experiences and their perceived success:

*My confidence levels have gone up. I had no confidence [before], but then on Monday when we were doing some work [in a mathematics education lecture] and [the lecturer] said to us "and that is algebra". I used to run a mile when I heard those words - algebra, trig and geometry, but I actually did it on Monday! (Louise, Interview 2.3)*

Other participants commented that they felt more confidence, particularly in the mathematics taught at primary school, which related closely to their chosen career. After Louise's comment above, Joanna responded:

*... I've gained confidence in the fact that the things you do you take for granted, but then to realise that in the context you're going to be teaching you actually do know your stuff. I feel quite confident that my maths knowledge is good, particularly to teach at the primary level. (Joanna, Interview 2.3)*

Also, Louise's comment indicated that she had to some extent overcome some debilitating feelings she had prior to the course. Four other participants also

thought that they had subdued incapacitating emotions about mathematics, including Karen who said:

*Through the lectures ... I think I have overcome my fear and hatred of maths because I can see the relevance of it so I will be able to teach it positively. (Karen, Interview 2.6)*

Karen also addressed the issue of relevance, which for many tainted their feelings about the subject.

Alongside feelings of confidence, 18 of the participants acknowledged feelings of enjoyment and happiness. In many of these cases (12) it seemed that their emotions were connected to the broader experience of the course in the learning and teaching of mathematics, including the personalities and characteristics of the course lecturing staff, but they associated their feelings to mathematics itself:

*It was a just a whole new way of looking at things - it was incredible! That was an amazing experience for me and even now it makes me want to cry. I'm so happy! The passion of the lecturers was amazing. They really wanted to make a difference for us and the kids we teach. I felt loved and cared for as I had to negotiate some really tricky issues and now I quite like maths. (Naomi, Interview 2.6)*

Others expressed positive emotions using adjectives and phrases such as satisfied (3), relieved (3), positive (3), motivated (2), excited (2), determined (2), amazed, incredible, “wanted to know more”, and “can do it”

Although most of the data collected during the second phase concerning feelings about mathematics was positive, there was a negative dimension. As part of their tertiary teacher education programme the participants were required to sit and pass a numeracy test (although this test was not part of, or connected to, their course on the learning and teaching of mathematics). For a group of six (mostly older) participants, their feelings about this test were closely related to their school experiences of mathematics and they were particularly anxious, or even paranoid, about it. Naomi, whose thoughts are recorded above, later in her interview commented:

*I'd like to feel even more positive but you know we still have that numeracy test coming up and I'm pretty anxious about that. Certainly*

*though, my attitude is changing but I think it will take time, and having to do this test isn't exactly helping!* (Naomi, Interview 2.6)

While these participants did express some negative emotions towards mathematics, their feelings weren't related to their mathematics education course. Furthermore, these were the only negative items identified in the data collected during phase two and so the overall feeling seemed to be positive.

### *The Participants' Feelings about Mathematics after their School-based Practicum (Phase Three)*

After the participants returned from their school-based practicum they commented again on their feelings about mathematics. In reviewing the data at this stage it seemed as if the participants were a little more dispassionate and less intense with their feelings in general. Perhaps not unexpectedly, their emotions were often related to how they thought the students might have felt in the classes they worked in on their practicum. Overall, about 40% of the data captured positive emotions and 60% negative.

The participants (7) who reported feelings of enjoyment towards mathematics described the mathematical pedagogy they experienced as being characterised by “games” and “fun”. It seemed as if their feelings were associated with the learning activities and class atmosphere during mathematics lessons rather than mathematics itself, which seemed almost irrelevant to their emotional response:

*Yeah, they were seven years old and they really loved playing the 'around the world' thing [a game where a student has to compete with one other child to answer a times-table question first]. They thought it was great fun and wanted to play all the time. I enjoyed maths and it showed that the maths really can be cool!* (Myra, Interview 3.6)

In the same vein, three of the participants also mentioned the class teacher who “made maths fun”, although it was the same teacher who taught all the subjects to the class. A small number (4) said they felt more confident with mathematics, and it seems that this was largely due to their realisation that the mathematics taught in primary schools is well within their comprehension.

However, a significant group (22) of participants were feeling not so positive after their school-based practicum. Again, for many of this group their feelings were closely associated with the classroom climate and pedagogical approach used in the mathematics lessons they experienced. Indeed, because it closely resembled the mathematics classes they had as a school student themselves, the practicum experience seemed to reinforce the feelings they expressed about mathematics during phase one. Interestingly, all of the participants who had their practicum in an intermediate class (Year 7 or 8) were in this category. The comments below all come from participants who worked in an intermediate school:

*Boring, maths was really boring. Honestly, I felt sorry for those kids! I spent most of my time going off into a dream. Maths, it is just dull.* (Janine, Interview 3.6)

*The kids hated math and so did I. I felt like I was back at school 15 odd years ago with boring textbooks and irrelevant stuff to teach.* (Warren, Interview 3.2)

*You can't enjoy maths because it is basically painful. In our lectures [the lecturers] could dress it up, but in reality it is something we have to do, but unless you are a geeky sort I don't think you could ever like maths! ... Only the geeks were good at maths in my class.* (Sally, Interview 3.3)

There was one participant who said she felt compromised during her practicum because “*the teacher wanted me to do a maths unit [on long division] that was irrelevant and boring. I found it hard because I didn't believe in the maths topic I had to teach, but to pass I did what she wanted*” (Kylie, Interview 3.3). Later in her interview Kylie seemed to get quite angry as she expressed a desire to teach mathematics as a meaningful and enjoyable subject, but she felt that she couldn't. She also shared her sense of disappointment for the children in the class, who she felt disliked mathematics, and she wished she could have used her opportunity to change their emotions.

### *Summary*

During each of the phases of data collection the participants expressed feelings and emotions about mathematics, and these seemed to be closely linked with their

particular experiences. The strongest emotions appeared to be connected with their school experiences when some of the participants used words like hate, terror and humiliation to describe their feelings about mathematics. At this stage their emotions were largely negative. However, their sensibilities were qualitatively more positive when the preservice teachers were sharing their feelings during and immediately after their tertiary course in mathematics education. During the final phase of data collection the participants were overall, less committed to their emotions concerning mathematics, but a significant number reported feelings that were similar to the ones they expressed during phase one.

### **Themes that Emerged Throughout the Data**

There were three topics that seemed to pervade all the data across the period of the study and these are outlined in this section. The first of these was “*the basics*” which all the participants seemed to perceive as being very important. The second was the need for mathematics to connect with “*everyday life*”, and the third theme was incidents that were perceived as being “*critical moments*” in their mathematical affective development.

#### *The Basics*

Within the whole qualitative data set there were many references to “the basics” with 29 of the 31 participants commenting on this topic at least once sometime during the study. Furthermore, the data concerning the basics came from all the phases and modes of data collection. The other striking feature of the data in this section was the strong consensus amongst the participants regardless of when they shared their thoughts.

Almost universally, the participants suggested that the basics were of fundamental importance, and that they were the essence of mathematics:

*I think maths is important because of the basics - you need to know the basics or else you won't get very far in life. (Brad, Interview 3.7)*

Unanimously, the basics were defined as addition, subtraction, multiplication and addition:

*Maths is addition, subtraction, multiplication and division - basics.*  
(Joanna, Journal)

*The basics are things like the main four - adding, subtracting, multiplication and division.* (Felicity, Interview 1.3)

*I still think the basics are important. The basics of maths is addition, subtraction, multiplication and division. We learn this from a young age and we use this until we die.* (Grace, Interview 3.2)

While all the comments defining the basics included the four arithmetic operations, some participants also added times-tables (6), counting (5), fractions (4), percentages (3), money (3), measurement (3), time (2) and problem-solving (2). Interestingly, most of these still relate to the number strand of the New Zealand mathematics curriculum.

The basics were seen as “the maths you learn at primary school” and were the foundation for the ‘non-basic’ mathematics learned at secondary school:

*The stuff we learned at primary school - the basics - arithmetic, measurement and counting. You know, real-world maths!* (Neal, Journal)

The comment from Neal above highlights the final feature of the basics as evident in the data, namely their usefulness in ‘real-life’. Many of the participants (21) suggested that the basics was the mathematics that one needed for life, and as mentioned above that was primarily arithmetic:

*Unless you are an adult in a heavily maths-related job or field, the maths you use in everyday, real-world situations is the basics - the stuff you learn at primary school.* (Joanna, Journal)

*It [the basics] are needed for everyday life. Just the general things like working out your money and the time. Just the basic maths.* (Aliesha, Interview 1.3)

*Well, obviously the basic multiplication, addition and subtraction are important for everyday life. Everyone uses that, but I mean I’ve never used trigonometry, vectors or any of that. .... And what is basic is what you’re going to use in the rest of your life - a survival package!* (Beverley, Interview 1.4)

*I think the basics are really important in maths, ... but some of the other stuff isn’t so important because unless you go into a certain line of work*

*then you won't need it, but if you need it, it is important. Some of the algebra and geometry isn't very important.* (Josh, Interview 2.6)

The application of mathematics to everyday life was seen as a defining characteristic of 'the basics' as illustrated above, but it also emerged as a significant theme across the whole data set, and it will now be outlined below.

### *Everyday Life*

Throughout the study, the participants commented on the difference between the mathematics they experienced as a school student and mathematics encountered as part of everyday life. Mike wrote the following entry in his journal:

*One seemed theoretical at the time, the other seems very practical at its time.*

*One involved a textbook, the other involves your wallet and time.*

*One had no effect on what you ate, the other determines whether you eat or not.*

*One seems almost a leisurely pursuit, the other a means to an end.*

*One had a face, the other had a bank statement or a bus ticket.*

*One appeared to last for 50 minutes a day, the other is here all of the day.*

*One you thought of as "one day I'll drop it", the other you view as "I cannot afford to!"*

*One taught you what negatives mean, the other what OD means.*

*One promised money, power and fame, the other delivers headaches, plane-tickets and the mundane.* (Mike, Journal)

While some parts of Mike's prose appears a little cryptic, it does convey some of the distinctions between school and real-life mathematics that emerged from the data. Their perceptions were that 'real-life' mathematics is useful, interesting, relevant, practical, purposeful, enjoyable and "learned on the job" whereas school mathematics is not useful, and is abstract and irrelevant. Furthermore, 'real-life' mathematics is used to solve relevant real problems whereas school mathematics is used to pass tests and exams:

*Real-life mathematics is learnt for a purpose from life experience - taught 'on the street'. Not so abstract.* (Sharon, Journal)



*School mathematics is the maths that you HAVE to learn to pass a certain year, whereas real-world mathematics is mathematics that you use in everyday life, like basic computing functions, percentages, etc. (Brad, Journal)*

A few of the participants (6) commented that when their experiences of school mathematics more closely connected with ‘real-life’ mathematics, then there was greater motivation to learn:

*In the third form I really enjoyed maths because I had a teacher who applied the equations to everyday life. We drew up plans of a dog kennel and we worked out how much wood was needed. Third form maths was fun, achievable, applicable and interesting. (Louise, Interview 3.2)*

Another participant (Mike, Journal) suggested that in his School Certificate year he did well in physics, which he perceived as being applied mathematics, but he did poorly in mathematics because he could see no application or relevance to his learning.

Some (4) also mentioned that often they did not recognise ‘real-life mathematics’ as mathematics because it seemed like such a natural part of their normal existence:

*I think real-world maths is interwoven into everything and you can't distinguish it out. You know, to say this is maths and this isn't maths, but you can't do this because maths is just a big part of life. (Joanna, Interview 2.3)*

To this end, they suggested that activities like shopping were good contexts for learning mathematics because they were inherently mathematical while simultaneously being integral to life. For some of these participants, the realisation that mathematics was indeed related to the so-called ‘real-world’ was a significant moment in their developing understanding of mathematics.

#### *Critical Moments in the Participants' Mathematical Affective Development*

On a number of occasions participants would identify critical events or experiences that shaped their beliefs, attitudes and feelings towards mathematics.

Many of these have already been mentioned in this chapter in various sections such as Grace and Caitlin who seemed to have been scarred by their embarrassing experiences at school, to Joanna who noted the tertiary sessions on the Fibonacci Sequence, Marina and Warren who highlighted the field trip, and Karen who saw the essay as pivotal. These will not be revisited here, but the key experiences of two other participants will be briefly outlined primarily in their own words. The first of these is from Neal who described a positive school experience that seemed to impact significantly on his attitude to mathematics. The second is Mike who described the year he was “turned off maths” and then the tertiary lecture that changed his perspective again.

In his first interview, Neal (aged about 45) described his mathematical experiences in Standard 4 (aged 10):

*In Standard 4, the first male teacher I ever had, this was in the Hutt Valley, had a friend who owned a, what I guess now is probably, a 30ft launch, and so he'd organised this guy to take us, take the whole class on a trip later in the year, a field trip to Ward Island in the middle of Wellington harbour, so most of the activities for the whole first six to eight months of the year, probably eight months I suppose, everything we did right across the board was related to that trip. So like we were doing, all our English was involved in writing letters to people asking permission to do things, asking for information, letters to our parents and they had to write one back to us, and then like nature study was all to do with the birds and insects and the fish around the island. And maths was all to do with drawing maps of Wellington harbour and working out how far it was between Somes Island and Ward Island and how far it was from Petone and all that sort of stuff. It just made life a little bit more interesting at school for a year. From that year on I really liked maths because, you know, it always seemed relevant and useful. That was a trip I wouldn't forget for a long time. (Neal, Interview 1.2)*

Neal's view that mathematics is “relevant and useful” seemed to have stayed with him, as about 35 years later on he expressed similar views several times throughout the study (i.e., his journal and interviews 1.2, 2.3 and 3.3).

In the same group interview Mike (aged in his mid-thirties) also recalled a critical year he had at school in Standard 1 (aged 7-8):

*I had a very bad, bad experience of maths. I had a teacher in Standard 1 who was very, very good at maths but he couldn't teach it and I got behind in Standard 1 maths, lost all my confidence and never regained it. And so the rest of the standards and into college I wouldn't say anything in maths because I knew I would proceed to be, I thought I was the worst in the class and it just made the whole thing worse. And I got to 5<sup>th</sup> Form maths and I did it because I had to do it. I knew I wasn't going to pass the first lecture in the year and I spent an hour in the School C maths exam and I kicked myself because I got 24 and I was only in there an hour and I knew when I walked out if I'd applied myself I could have done it. But I found that it impacted my career because when it came to 4<sup>th</sup> Form, 5<sup>th</sup> Form career guidance, anything that involved maths I just dismissed as a career so it had beaten me. (Mike, Interview 1.2)*

On other occasions Mike reiterated his feelings about mathematics and how his year in Standard 1 had impacted on his life subsequently. However, in his second interview he recounted a second critical event:

*For me it happened about a fortnight ago really when [the lecturer] talked to us about BEDMAS and the order of operations and I was able to pinpoint that way back in my maths schooling as the point where I went off the track. It was a whole new concept to me and looking back now I can see why by not getting that basic thing. And so for me the highlight was that there occur things in maths that I need to - you know just one little thing in my classroom can actually have impact, or potentially could impact, so being aware that key things are there and important. I found that just the whole thing has changed my attitude to maths. I mean I never really hated it but I think I sort of saw it as one of those necessary but not particularly interesting subjects. And my focus changed I noticed and I'm able to be more enthusiastic about it than I would have been. (Mike, Interview 2.3)*

The moment of understanding experienced by Mike seemed to be the trigger for his positive affective reform. The second event seemed to provide a positive event to replace the traumatic experiences of 28 years ago, and he was clearly able to

“pinpoint” the concept concerned. In the following chapter some other critical moments are captured in the case stories of two of the participants in the study - Marina and Brad.

## **Summary**

In the previous chapter the quantitative data was presented to highlight the trends and changes that occurred during the study. This chapter has in a sense ‘fleshed-out’ those features by recounting the participants’ voices on the issues of concern. While of necessity a report such as this needs to be written in a linear format, it is the interplay and complex relationships between the various aspects that is important, and in many respects it is the overall picture of this chapter which is the data rather than the individual, isolated sections.

In this general sense, the data presented in this chapter supports and confirms the patterns evident in the quantitative findings. While individual participant stories varied, the general picture was again that at the beginning of their initial teacher education programme, many were negatively disposed towards mathematics. These negative views (or otherwise) were closely associated with their school experiences, particularly secondary school and their mathematics teachers. After their first tertiary course in the teaching and learning of mathematics, the majority of the participants had a more positive view of mathematics and more helpful beliefs about mathematics and mathematics pedagogy. Finally, after their school-based practicum, their affective views varied from some who were still positive to others who had returned somewhat back to their initial beliefs, attitudes and feelings. This seemed largely to be dependent on the nature of their practicum experience. In the following chapter some cases will be presented to more vividly convey some of the findings of the study.

## Chapter 6: Case Studies and Stories

This chapter bridges the previous two data chapters and the following discussion chapter by conveying some of the data in more narrative form. The chapter will be split into two distinct parts. The first section follows two particular participants through the three phases of the study. The second part focuses on one of the key features of the data, that being the participants' mathematics teachers.

### The Cases of Brad and Marina

In the previous data chapters changes in the participants' affective responses towards mathematics have been evident. These case studies are presented simultaneously to try and show the development and changes that occurred across the 12 months of the study. Brad and Marina have been chosen because their data are rich and detailed, and they illustrate some of the major findings of the study. However, these two were fairly typical of the participant group, not exceptional cases chosen for dramatic effect. Brad came straight to teacher education from secondary school where he had been a successful sportsman and school leader. Marina was in her late twenties and she started her tertiary teacher education with a range of life experiences. Where possible, the participants' own words have been used.

#### *Experiences as a School Student*

Generally, the participants could remember little of their mathematics at primary school other than having quizzes and tests on their "times-tables". Marina recalled feeling "quite dumb in standard one" because she couldn't recite all her tables quickly, and her teacher had made her write them out several times during the lunch-break. In her first interview she said:

*I know that knowing your times-tables is really important – probably one of the most important things you need to learn at primary school, but I'm still not too confident about my sevens and twelves. I think this is something I'm going to have to brush-up on if I am going to be a teacher!*

Brad remembered playing with some “coloured sticks” (Cuisenaire rods) and his times-table tests every Friday. He suggested that the key to passing these tests was not necessarily to know the answers, but to sit next to someone who did and, when you could get away with it, mark your own test.

Both Brad and Marina could recall greater detail of their secondary school mathematics classes, and indeed both described in great detail some of their teachers. Below (Figure 6.1) are the pictures they drew of their mathematics teachers.

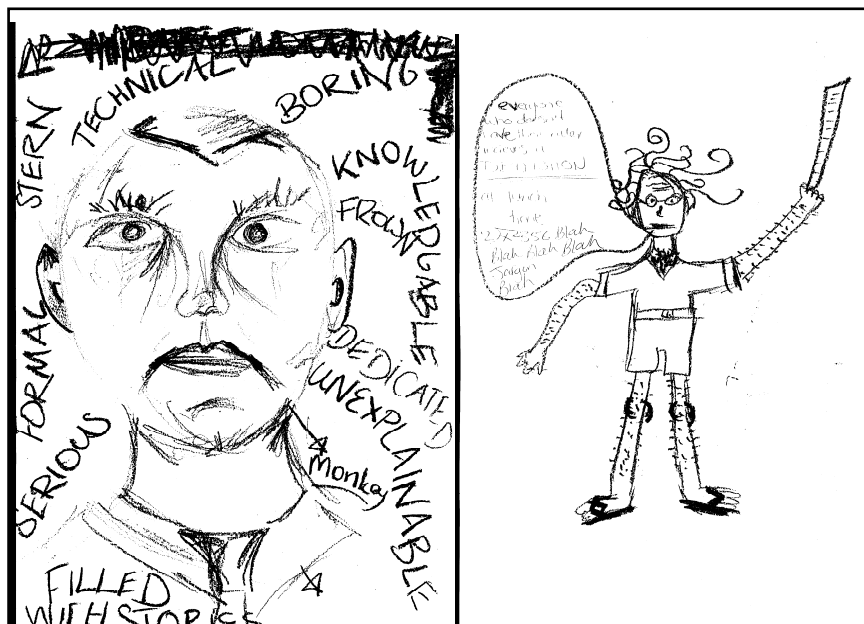


Figure 6.1: Marina and Brad’s drawings of their mathematics teachers.

However, neither of them could recall a mathematics teacher they liked or respected, in fact they described their teachers as being sarcastic, uninterested and incompetent. Brad described his year 10 mathematics teacher:

*Mr Howard was good at maths himself, but he couldn't relate to me. I was into sports and he wasn't, and he thought I just wasted all my time playing rugby and cricket when I should have been studying. When I failed a test or didn't get something he'd just say that I needed to do more work and spend less time chasing balls. ... I really hated him in the end and I just gave up.*

He said that after his year with this teacher, he basically gave up on mathematics and didn't try to understand it until in his last year when he thought he needed to pass mathematics to get accepted into a teacher education programme.

In describing their mathematics classes, the experiences of the two participants sounded remarkably similar, regardless of year level, teacher or school. Below is part of one of Marina's descriptions she wrote in her journal:

*Class began with the teacher explaining stuff from the blackboard with heaps of notes for us to copy down. Then he would do two or three examples which we also copied down. At this point most of us were confused! We would be set some pages of work to do from the textbook, and after we ruled up our books properly we would do the exercises. Most of the time we'd copy the answers from the back of the book, although sometimes the teacher wanted to see some working. At the end of the lesson we'd get told to complete the exercises for homework.*

Brad's experiences were almost identical to Marina's, and Marina's didn't seem to vary through the different levels of her secondary schooling.

After their experiences of mathematics at school, both participants thought that mathematics was important, but neither of them knew why. Furthermore, they described mathematics as being mostly about numbers and "the basics", irrelevant to life, mysterious and difficult for all but "geniuses" to understand. Marina added that she was also very anxious about having to do "mathematics courses" as part of her teacher education as she was a "maths dummy". Brad also said that he was "mathematically challenged", and he'd do it because "it was important for kids to learn maths" even though it was "largely irrelevant".

#### *Experiences in Their Tertiary Teaching of Mathematics Course*

The students undertook a course in the teaching of mathematics during the first semester of their teacher education programme. This course involved two 90-minute sessions a week for twelve weeks and its rationale espoused a constructivist approach to teaching and learning mathematics. Their classes

incorporated a range of activities including lectures, workshops, readings, role-plays, discussions and field trips. After the course, Marina commented:

*I loved the course! I never thought I would have said that about a maths class! Maybe it is just because I am older and more focussed now, but I do enjoy maths and I can see it all around me everyday. ... Matt [one of the course lecturers] was really interesting and passionate about his stuff – maybe I have caught this love of maths off him! He spent time with me, explained things and challenged me to look at maths again. He even helped me with my times-tables!*

Brad also wrote:

*Yep, it was primo! I had a lot of fun and enjoyed the classes, which is a change. I thought the field trip was cool – it showed me that maths is useful and all around us. I can see that maths is more than just working from a textbook and blah, blah, blah from the blackboard. ...*

They still thought that mathematics was important and that “all kids need to know the basics”, the basics being arithmetic, times-tables and fractions. However, both participants also emphasised the need to “understand mathematics rather than just being able to do it”, and that mathematics was relevant to life outside the classroom.

#### *Experiences During Their School Practicum*

Marina’s practicum was in a year three class in an innovative school that was involved in the Early Numeracy Project (ENP). Marina’s associate teacher allowed her to have a small group of students for mathematics each day and encouraged her to try out some of the ENP material. Marina said that “her teacher was a treasure who really loved the kids”, and in her mathematics teaching “Beryl always tried to make learning fun and relevant – she was setting them up for success”. In reconciling her practicum experiences with her prior views Marina commented:

*That stuff that we learned in lectures [in the mathematics education course] was spot-on. On the prac I could really see how kids can be switched onto maths – about teaching to their hearts as well as their*



*heads! Kids can actually enjoy maths – amazing – I never thought it would be possible!*

Clearly there was a sense of astonishment for Marina in seeing mathematics differently, although she later acknowledged:

*It is still a struggle. If I don't consciously think about it then I go back to my old ways and I become anxious and rigid. ... It's like a bad habit of the brain, something I need to consciously and consistently work on or else I go back to thinking [about mathematics] how I did before.*

For Brad, his practicum experience was quite different. His time was spent in a year seven class where they were streamed and they followed a “traditional mathematics program”. Brad described the mathematics classes he experienced:

*Every lesson was the same. The teacher had a blue folder with all the worksheets for the unit, so after their pre-test the kids would chug their way through the worksheets one at a time until the end. After three weeks, the teacher gave them the test. The teacher had a few notes on the board at the start of each lesson which some of the kids copied down, but she never really taught them stuff from the front. ... It was boring man and I nearly fell asleep sometimes!*

When asked to reflect upon his experiences he commented:

*I think that stuff we learned with [the mathematics education course lecturer] was fun, but when it comes down to it, it doesn't work in real teaching. ... Kids can't do step 42 if they don't get step 41, and so you need to teach everything step by step. This is hard with 30 kids in the class but streaming definitely helps. ... The students have to know the basics.*

Interestingly, although Brad expressed little enthusiasm for the mathematical pedagogy he experienced on his practicum, his views about mathematics and mathematics teaching seemed to be consistent with those of his associate teacher.

### *Discussion*

The cases of Marina and Brad exemplify some of the main findings of the study. Firstly, the participants perceived their school mathematics as a negative experience, which caused them to develop feelings of anxiety and inadequacy.

Furthermore, their experiences were consistent with absolutist and instrumental views of mathematics as is evidenced by the emphasis they placed on times-tables and “the basics”. Even though Brad had been at school immediately prior to starting his initial teacher education, and Marina had not been to school for at least 12 years, their school experiences were remarkably similar, despite a major curriculum reform which occurred in between. Both of their experiences were characterised by teaching that was narrow and based on a transmission-model. This facilitated the development of Brad and Marina’s affective views of mathematics, which they brought to their tertiary teacher education programme.

Marina and Brad’s affective dispositions seemed to change for the better after their participation in their tertiary mathematics education course. This was probably a predictable outcome, and indeed one would be worried if such a course facilitated no growth in beliefs about mathematics, or change in attitude towards the subject. However, it was fascinating to note the continuing strong conviction and commitment to times-tables as being important.

The experiences of Brad and Marina had been similar in many respects up until this point, but during their school placements they encountered mathematics education in different ways. Their experiences during practicum were critical events in their affective development and they indicate the power of the practicum placement to support or undermine the learning of the tertiary course. For Brad, the experiences seemed to be confirming his views prior to entering his initial teacher education programme. Perhaps it was because his practicum experiences matched his own school experiences that this reality was too strong for him to be able to hold onto a different way of thinking about mathematics, mathematics teaching and learning acquired during the maths course. For Marina however, her practicum experiences continued to support her new perspective of mathematics and she was able to continue her affective growth in a positive and healthy ways. Interestingly, she was still able to note the struggle she had as she fought against previous views that she described as her “default mode”.

## **School Mathematics Teachers**

One of the most significant features of the qualitative data was the prominent place teachers had in the participants' recollections of their experiences in mathematics, and this was evident in the case studies of Brad and Marina above. Early in the study this became clear, so the participants were asked to draw a picture of their mathematics teachers and a selection of these are included in Appendix I.

Often when the participants were asked about mathematics, they talked or wrote about their mathematics teachers, and regularly described in great detail their personal characteristics. Particularly in the interviews, and to some extent in their drawings, the participants' reminiscences were often accompanied by a degree of emotion and feeling that ranged from delight and respect to fear, shame and hatred. Primarily the teachers they recalled were male secondary school teachers, and generally the participants could pinpoint "the teacher who put them off mathematics".

When analysing the participants' descriptions of their mathematics teachers, three clear categories emerged and these are illustrated by the three fictional characters described below. The three teachers – Mr Wilson, Ms Craigie and Mr Brock, were synthesised from the participants' descriptions in the data collection activities and often their own words have been used.

### *Mr Wilson*

Mr Wilson is a middle-aged man who has been teaching mathematics in secondary schools for many years. He has a degree in mathematics and he knows his subject well. His dress is conservative, he generally wears a tie, and he keeps a well-groomed beard. Apart from teaching mathematics, he also coaches the school's rowing team. Mr Wilson's classroom has the desks organised in single rows, his desk at the front on the left, and a substantial blackboard as its focus. On this blackboard he presents to his classes meticulously presented notes on the topic for each day, with two or three worked examples for students to follow. He covers this material in a quiet and methodical manner, and then sets the students

to work on exercises from their textbook. While they work on these exercises, he works his way around the room interacting with all the students, checking their understanding and asking the occasional question about their weekend netball game or trip away. When he talks with the students he bends down beside their desk and, from under his bushy eyebrows he looks them in the eye and listens intently to what they say. One student, Louise, said that he reminded her of her dad! Mr Wilson is well liked and respected by his students who appreciate his patient, approachable manner, and they know he is interested in them personally as well as academically.

### *Ms Craigie*

Ms Craigie has been teaching on and off for many years, although only in the last few years as a secondary school mathematics teacher. She has a primary teaching diploma which she completed 31 years ago. Behind her back, one student, Michelle, often commented that “she is stuck in a fashion time-warp”, although she did acknowledge that some of her clothes were in keeping with the current *retro* fashion. In her teaching, Ms Craigie relies heavily on the textbook, getting students to copy the notes and examples from the start of a section, then work their way through the corresponding exercises. Students mark their own work from the back of the book. Her HoD can be confident that she will cover all of the curriculum during the year because she keeps to the set schedule whether the students understand the material or not. Classroom management is a constant battle for Ms Craigie and she is constantly annoyed by the silly behaviour of some of the boys. Generally she seems quite distant from the students and she rarely smiles in class. Students lack confidence in her ability to teach them and they sense she is not very excited about mathematics or about them. Actually, Zane described her as “Miss Martian” because to him she seemed to come from another world!

### *Mr Brock*

Mr Brock loves mathematics and he is a brilliant mathematician. Almost all of his students would acknowledge that he is a very clever man, and yet few of them want to be in his class. Mathematics was easy for Mr Brock, and he struggles to

empathise with those who don't share his ability or passion. Of course there were those four boys in the Year 13 Calculus class who got all his attention – they are his special group who are going for 90% this year. Many of Mr Brock's students grew to hate mathematics despite his great love for the subject, as was expressed by Warren:

*He [Mr Brock] was amazingly intelligent when it came to maths. He knew every formula known to man. But could he teach? ... NO! He didn't have a teaching bone in his body, nor did he have any patience for anyone who lacked understanding of maths. I had always enjoyed maths growing up, but during those years I lost all interest in it.*

To control the class Mr Brock can put students in their place quickly with a belittling response or a sarcastic comment. Some of the girls particularly resented him for this, and Aliesha reckoned that she didn't speak to Mr Brock for all of terms two and three because she was too scared. By the end of their year with Mr Brock, a couple of students excelled in their examinations and chose to continue with mathematics the following year, two or three students *scraped through* but chose not to do any further maths, and the rest failed miserably, hated mathematics, and went on to avoid mathematics at all costs.

## **Summary**

The descriptions above reflect the three broad categories of responses made by the participants, but by far the most common were teachers like Mr Brock. Around two-thirds described a teacher of his style, and in their pictures several were depicted with horns and a pitch-fork (see Appendix I). Perhaps the significance of the data presented above is not just the content of their descriptions, but also the context in which these descriptions were given. The normal response for many of the participants to questions and probes about mathematics was to express views about their teachers, and usually their secondary school teachers. Their teachers were, if not the main source, a primary factor in the development of their beliefs, values, attitudes and feelings about mathematics.

While there are probably many stories that could be told from the data, the two foci selected represent prominent aspects of the study's findings. The case studies of Brad and Marina highlight the patterns that emerged in the participants' affective responses to their various experiences, and thus gave more meaning to the longitudinal nature of the project. While Brad and Marina's perceptions of their mathematics at school was disappointing, and the changes that occurred through their tertiary mathematics education course more encouraging, the power of the school-based practicum to moderate their affective views was revealing.

While quite distinct from the case studies of Marina and Brad, the descriptions of the three fictional mathematics teachers were also revealing. They showed the clear and detailed way the participants recalled these people and how their perceptions of these teachers impacted on their perceptions of mathematics itself. The unfortunate perception of many of the participants indicates that there may be a serious issue for the mathematics education community. This issue, amongst others that emerged from the data, are discussed in the following chapter.

## Chapter 7: Discussion

The purpose of the study was to explore the influence of experience on the beliefs, values, attitudes and feelings of preservice primary teachers towards mathematics. In Chapter Four the quantitative data were analysed and reported and, in Chapter Five the qualitative data were examined and presented. In Chapter Six some case studies and stories were used to illustrate some of the key findings of the study. In this chapter the data collected throughout the three phases of the study are briefly synthesised and compared with the literature in the field. Given the phenomenological methodology of the study, the discussion is largely descriptive, although many of the findings are explored through appropriate theoretical ideas.

This chapter begins with a discussion of the connections between the three phases of the study and the symbiotic relationship between mathematical experiences and affective views about mathematics. This is followed by a series of more specific discussions focusing on the following aspects:

- the influence of school mathematical experiences on affective views about mathematics;
- the relationship between affective views about mathematics and preservice teacher education in mathematics teaching and learning;
- the influence of practicum experiences on affective views about mathematics.

The discussion then turns to the trends and exceptions that emerged in the affective responses of those who were initially positive and those who were initially negative. Next, there is a brief consideration of the affective domain particularly as it relates to teachers and mathematics teaching. The chapter concludes with a discussion of the limitations of the study.

In the findings of the study, three major issues emerged and these will be particularly highlighted in the ensuing discussion. These significant issues were: (1) the influence of the mathematics teacher; (2) the need for preservice teacher education to address the affective domain; and (3) the influence of the practicum.

As these three topics arise in the discussion they will be particularly highlighted and discussed in greater depth.

### **The Relationship between Mathematical Experiences and Affective Views about Mathematics**

An initial aim of the study was to explore the links between experience and affective responses and the diagram presented in Figure 7.1 (page 148) is an attempt to show graphically the relationships between the data that emerged. Inevitably, any diagram will be a simplification of the situation as it is impossible to fully grasp the complexity of these relationships, and indeed these may vary from participant to participant. Nevertheless, the diagram does seem to capture the essence of the data as collected and analysed throughout the study.

Both chronologically and conceptually, the diagram starts with *school experiences of mathematics* (bottom left-hand corner). The nature of the study meant that these events and experiences were historical and unchangeable, meaning they were a part of the mathematical foundation that participants brought with them to their initial teacher education programme. It was also here that their deepest and most significant affective responses to mathematics seemed to be developed, and these views in turn impacted on their experiences of mathematics and their developing mathematics pedagogy over the first year of their preservice teacher education. This is indicated by the uni-directional arrows going from the *Experiences of mathematics as a school student* section to the other two major ovals.

The longitudinal nature of the study that traversed the participants' first year of their initial teacher education programme meant that the study was able to uncover an interactive relationship between their experiences and their affective views. While the participants' school experiences of mathematics could only be reviewed retrospectively, their developing affective responses to mathematics throughout the first year of their programme, particularly their mathematics education course and practicum, were investigated in a more dynamic manner. This is indicated by the two-headed arrow between the two corresponding major ovals on the diagram.



In general, the study revealed that experience had an influence on the beliefs, attitudes and feelings of preservice primary school teachers towards mathematics. The influence of experience was noted in the literature, in particular Green (1971) and Rokeach (1968) with respect to beliefs, Carroll (1994a) and Owens, et al. (1998) with respect to attitudes, and McLeod (1992) with reference to emotions. Furthermore, the affective views developed from experience were seen as primary, and were powerful determining factors whereas affective responses developed in other ways were less significant. Nespor (1987) theorised that beliefs were held in episodic memory, couched in significant previous events and this was borne out in the data where many of the participants were able to identify critical events that significantly shaped and directed their affective responses to mathematics. The general relationship between experience and affect is now discussed with reference to the particular realms of mathematical experience that structured the study.

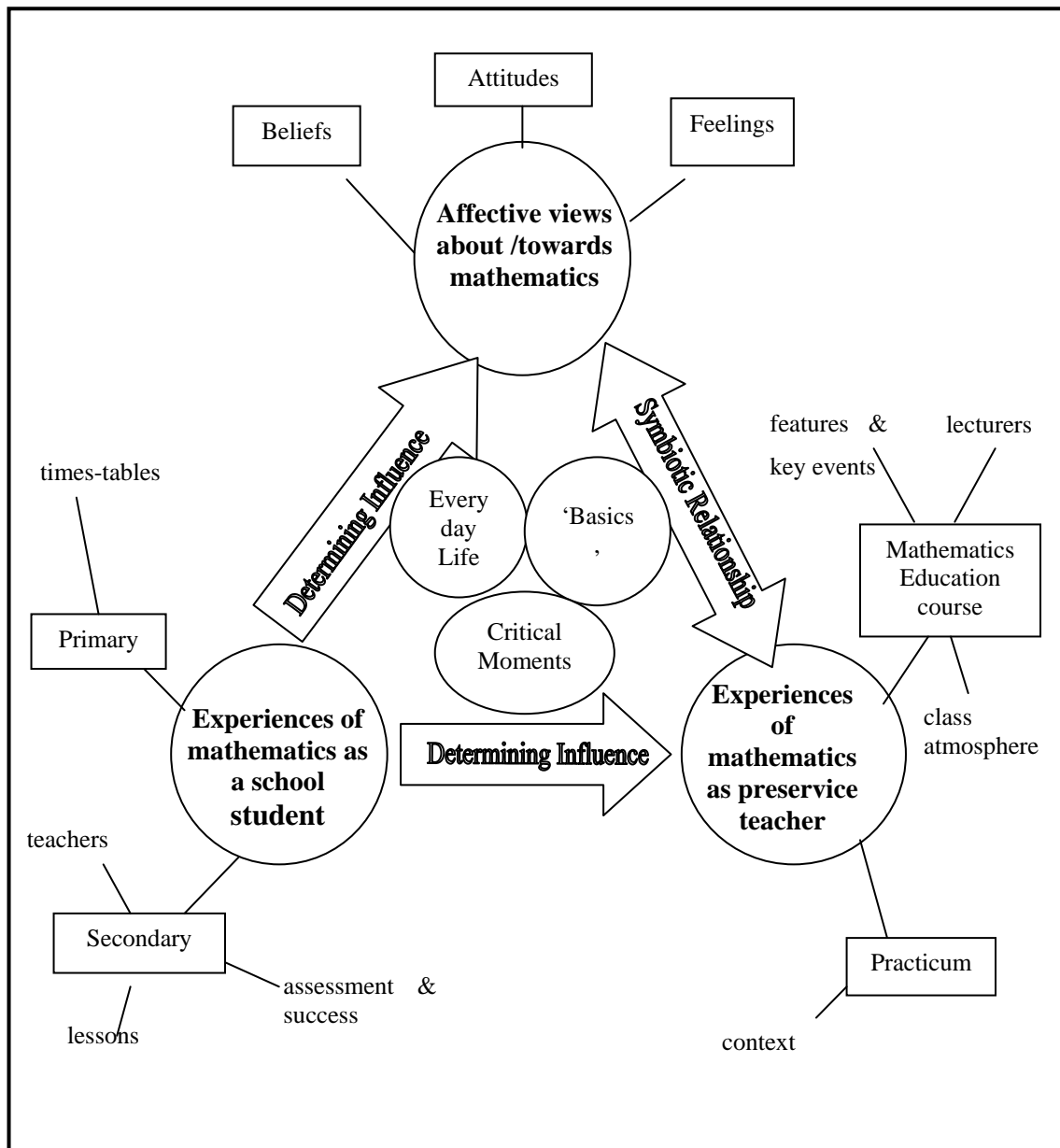


Figure 7.1: The interplay of experiences and affective views throughout the study

## **The Influence of School Mathematical Experiences on Affective Views about Mathematics**

The participants' experiences of mathematics as a school student were fixed in history and therefore, only available as data through the recall of memories and perceptions. For some of the participants, school experiences occurred some 30 years ago and in countries as far abroad as England, Egypt and South Africa. Despite the relatively large time lapse between the participants' school experiences of mathematics and the data collection, their accounts were extremely vivid and detailed. Furthermore, the display of emotion that accompanied some of the participants' recollections indicated that their memories were far more complex than mere factual details of certain events indicate.

There is strong support in the literature for the idea that peoples' affective views about mathematics are largely a result of their school experience (Frank, 1988; Lim, 1999; Thompson, 1984). Ernest (1996) suggested this was the case because:

all members of the public in modern industrial societies spend many years as students of school mathematics. .... [and therefore], experiences in school mathematics form the basis for the image of mathematics constructed by learners, especially negative ones. These in turn are a major source - perhaps often the dominant source for the public's image of mathematics. (p. 810-811)

The findings in this study were consistent with the work of Lortie (1975) who suggested that preservice teachers undergo an *apprenticeship of observation* as they experience teachers and teaching through their years as a school student. He suggested that these experiences are where preservice teachers develop their primary beliefs, values, attitudes and emotions about teaching and the subjects they teach. It appears that during their schooling, perhaps unknowingly, the participants learned many things about teaching as they participated in the social life of the classroom, and in doing so, they constructed beliefs about what a teacher does (Lave & Wenger, 1991; Rogoff, 1990). Certainly a number of researchers suggested that this was particularly the case in regards to mathematics and the findings of this study are consistent with this view (Biddulph, 1992; Bobis & Cusworth, 1994; Carroll, 1994a; Cooney, et al., 1998; Davies & Savell, 2000;

Grootenboer, 2000; Gustafson & Northfield, 1994; Joram & Gabriele, 1998; Klein, 2001; Mayers, 1994; Nesbitt Vacc & Bright, 1999; Schuck, 1998). This might not be a problem, except that it seems as if many preservice teachers have poor or negative perceptions of their school mathematics experiences, and their associated affective responses to mathematics are also correspondingly negative. Ball (1990) explained this by mapping a cycle of negative affective views towards mathematics amongst primary school teachers.

The data presented here show that most of the participants held negative affective views about mathematics after their experiences as a school student. Given the accounts many of them presented of their school mathematics, this was not surprising. In the following sections the key aspects of these experiences as recounted by the participants are discussed and some possible explanations explored.

#### *Primary School Experiences*

While the majority of the data about their school mathematical experiences related to their secondary schooling, there were some interesting patterns in their recollections of primary school mathematics. It was difficult for many of them to distinguish mathematics from their other subjects because they were all taught by their classroom teacher in their own classroom. What was prominent was the special and revered status times-tables had in their perceptions of mathematics. All the participants, regardless of age, felt that it was very important for them to memorise their times-tables as a fundamental part of their primary school mathematics education. Proficiency in memorising times-tables was seen as an indicator of being good at mathematics, and vice versa. Indeed, recent research seems to indicate that this is still the case amongst primary school children today, at least in New Zealand (Grootenboer, Romley, Stewart & Thorpe, 2002).

The participants' views of times-tables had particular implications for their conception of mathematics and learning mathematics, their perception of themselves as mathematics learners, and their developing beliefs about teaching

mathematics in the primary school. Firstly, when outlining their initial beliefs about the nature of mathematics, the most salient aspects were that mathematics is about numbers and number operations, and it is characterised by absolute, clear-cut truth that is best learned through rote learning and memorisation. Furthermore, the participants expressed a belief that *the basics* are very important and foundational to mathematics, and generally the basics were seen to include times-tables. Clearly these views could be linked to the experiences the participants' recalled of times-tables at primary school, and while there may be some value in learning multiplication facts, there would be much debate as to whether they constituted the essence of mathematics.

Also, given the emphasis the participants placed on *memorising* their times-tables, it seems plausible that participants perceived success in mathematics as based on an ability to memorise and recall rather than learn and understand. As Chapter Five shows, for some of the participants the ability to memorise their times-tables seemed to be a significant factor in their perception of themselves as mathematics learners generally. This was illustrated in the case of Marina (Chapter Six) who expressed a feeling of inadequacy based on her inability to quickly recall some of her times-tables.

Given that the participants in the study were preservice primary school teachers, there was also apparently a corresponding impact on their developing mathematical pedagogy. It seems that times-tables were seen as a valued 'cultural activity' in the classroom, and through their peripheral participation in this practice, the participants also came to accept their value (Lave & Wenger, 1991). While this was not the central focus of the study, it was apparent that many of the participants were firm in their belief that times-tables had a critical part to play in the mathematics education of their future classes, and this seemed largely unchanged throughout all the data collection phases. It appears then, that this particular aspect of their primary school experience has formed a significant part of their *cycle of affective views about mathematics* (Ball, 1990).

### *Secondary School Experiences*

The findings of this study are consistent with other literature showing that at secondary school many students develop negative affective responses to mathematics (Biddulph, 1992; Carroll, 1994a; Cooney, et al., 1998; Grootenboer, 2000; Gunstone & Northfield, 1994; Hubbard, 2001; Joram & Gabriele, 1998; Kogelman & Warren, 1978, Lim, 1999). While there may be a number of reasons why this occurs, it appeared that there were three key factors, the most critical one being their mathematics teachers. However, before discussing the data relating to their teachers, the other two aspects concerning their lessons and assessment will be briefly explored.

The participants attended secondary school some time between the early 1960's and the year 2000; however, the structure and content of their lessons seemed remarkably similar. Over this period of time, New Zealand has had at least three different mathematics curriculum statements, each significantly different from one another. The pattern of lessons appears to be 15 minutes of teacher explanation and note taking, 10-15 minutes of worked examples on the board, and then exercises from the textbook that were (supposed to be) completed for homework. Key features of the mathematics at secondary school were the use of textbooks and exercise books, formal seating arrangements, and streamed classes. Given these experiences, and the uniformity of many aspects of their accounts, it is not surprising that many of the participants saw mathematics as a rigid, unchanging subject akin to Ernest's (1989) "Platonist view". Hersh (1985) suggested that this view of mathematics as infallible, fixed and certain was not consistent with the true mathematical endeavour, and yet this is what the present study shows, like many others reported in the literature (e.g., Aldridge & Bobis, 2001; Ball, 1990; Cooney, et al., 1998; Joram & Gabriele, 1998; McLeod, 1992; Schoenfeld, 1989). This is the very view that many are developing as a result of their secondary school mathematics education. Of further concern for preservice teachers is that these beliefs about mathematics have been linked with particular views about teaching and learning mathematics. The content-focused approach (Kuhs & Ball, 1986) that seems to prevail is usually associated with a mathematical pedagogy that is characterised as *teaching by telling* (Buerk, 1985; McLeod, 1992; Stipek, et

al., 2001; Thompson, 1992). Again, Ball's (1990) *cycle of affective views about mathematics* seems apparent.

The second aspect that emerged from the participants' descriptions of their secondary school mathematics experiences concerned their assessment and their perceived success (or otherwise) in learning mathematics. The forms of assessment experienced were mostly tests (at the end of a unit of work), examinations, and for some a statistics project. The tests and examinations largely involved the recall of previously learned mathematical content in a pencil-and-paper format within a limited time frame. As with the lesson formats discussed above, these forms of assessment seem to be consistent with Ernest's (1989) Platonic view of mathematics - a view which predominated in the participants' initial conceptions of the subject. The statistical project noted by some of the participants was more closely related to the instrumental view of mathematics identified by Ernest (1989), and again this utilitarian view was evident in the participants' initial beliefs about the nature of mathematics. While it would be overly simplistic to suggest that these forms of assessment determined the participants' conceptions of mathematics, it does seem feasible that combined with the lesson content and formats they experienced, their beliefs were significantly influenced. Other researchers have noted similar views amongst preservice primary teachers (Aldridge & Bobis, 2001; Mayers, 1994; Sowder, 2001; Stipek, et al., 2001), suggesting that these views may indeed be common within this group, and therefore, an issue of concern for mathematics educators.

Allied to their assessment experiences were their perceptions of themselves as successful or otherwise, in learning secondary school mathematics. In exploring the school mathematical experiences of their participants, Buerk (1985), Carroll (1994a, 1994b) and Thompson (1984) all concluded that poor performance in formal assessments led to negative feelings about mathematics. In the study, most of the participants reported ending their formal mathematics education after they "failed", and therefore, their final feelings about the subject are related to their final unsuccessful year of study. In reflecting upon people's feelings about mathematics in general, Hubbard (2001) concluded that students finishing their

mathematics education in failure was a major issue in the public's general dislike of the subject. Again, this issue is of particular concern for preservice primary teachers who will have to teach mathematics to their classes and hopefully approach this with enthusiasm and passion. Indeed, the participants suggested that their teachers were the single most important factor in determining whether they were successful in their mathematical learning, and if they liked or disliked the subject.

### **Major Issue 1: Mathematics Teachers**

There were three major issues that emerged through the study, and this section addresses the first of these issues – the influence of mathematics teachers. This was a somewhat unexpected finding that emerged early in the study and therefore, it was explored further through all the data collection phases. It seems that the salience of mathematics teachers is not well documented in the mathematics education literature and therefore, this study contributes new insights to the research. Indeed, it appears as if secondary mathematics teachers have the power to largely determine how people perceive and feel about the subject in the years following their schooling. Unfortunately, many of the participants in this study had perceptions of their teachers which were not positive (as illustrated by *Mr Brock* in Chapter 6), and they seem to have developed correspondingly negative views of mathematics. While there appear to be only a few studies on students' perceptions of their mathematics teachers, these emerged as a critical factor in the participants' affective views of mathematics in the present study. Two recent studies (Picker & Berry, 2000; Lim, 1999) revealed that secondary school mathematics teachers were a significant factor in the public's images of mathematicians and mathematics. Lim argued that “most students when asked to recall their mathematics learning at school often remember their mathematics teachers in relation to their personality or their methods of teaching” (p. 61). The findings of the present study are consistent with this claim. McSheffrey (1992) also found that the feelings about mathematics of the adult participants were substantially influenced by their secondary school mathematics teachers, which was a finding that was also replicated in this study. Indeed, the mathematics



teachers of the participants featured prominently throughout the study, particularly in the qualitative data presented in Chapters 5 and 6.

### *The Gulf Between Teachers' Intentions and Student Experience*

Given the strength of the data relating to the influence of secondary school mathematics teachers, combined with the associated findings in the literature, there is clearly an issue of concern. It is indeed troubling when individuals' experiences of mathematics teachers are at worst, a public flogging of humiliation and exposure that results in debilitating beliefs and attitudes, and feelings of anxiety and fear. It is hoped that mathematics teachers do not deliberately set out to humiliate their students and create negative feelings about the subject, but in many cases it seems as if there is a huge gulf between the intentions of the teacher and the experiences of the student.

While there are no doubt a number of reasons and theories for the apparent gulf between the teachers' intentions and the students' experiences, there appears to be little reported research, at least in the field of mathematics education. In the research into the affective domain in mathematics education, a methodological issue may partially account for this gap in the literature. This study, like most that explore affective aspects of mathematics education, employed self-reporting methods of data collection. Few studies were classroom-based. However, it seems as if an issue like the 'gap' outlined above would need to be investigated within the teaching-learning milieu. One exception is the *Values and Mathematics Project* (Bishop, et al., 2001) where they have researched values in the classroom context and they have deliberately examined the intended and enacted values of teachers. It was interesting that the current study did not seem to reveal a great deal about the participants' values, and maybe this was, at least partially, due to the methods of data collection employed.

When some of the participants recounted their perceptions of the mathematics teachers they did not like, often poor classroom management was a factor. The use of sarcasm and other demeaning management practices seems to have been a

significant aspect of the participants' mathematical experiences, and while this was not related to the subject, it became connected to mathematics by association. While it seems like a loose coupling of two disparate things (mathematics and classroom management), there is an issue here that requires the attention of mathematics teachers and educators, because the students' association of these aspects appears to have had a detrimental effect.

Fraser and Spiller (2001) suggested that "effective teachers seem to have a blend of certain personal attributes and pedagogical skills" (p. 68), including respect for students, sound management skills and a passion for their subject. Palmer (1998) also highlighted the intersection of personal and the professional as being the place where teachers work, and it is the milieu at this point that is critical to effective teaching. This site is precarious and the complex network of relationships it navigates can indeed yield unexpected results, not the least being students who dislike the subject matter of mathematics because their teachers were perceived as being poor managers of students' classroom behaviour.

The issues surrounding curriculum and assessment are related to mathematics education rather than mathematics per se. There seems to be pressure on mathematics teachers to complete the curriculum or prescription, meaning at times that they have to move onto the next topic or unit even when a number of students do not understand or comprehend the material at hand. This may have led the participants to perceive their teachers as unhelpful and disinterested in their learning. Furthermore, the assessment of student learning through examinations and regular tests constantly highlighted the perceived inadequacy of many students, and the students then see their mathematics teacher as the constant 'bringer of bad news'. Certainly there has been much written about educational assessment, and even in mathematics education, many have promoted the benefits of employing a range of assessment modes (e.g., Bobis, Mulligan, Lowrie & Taplin, 1999), but it seems as if the experience of many students is still limited to the traditional tools of tests and examinations. Perhaps this is partly why mathematics is still perceived in an absolutist fashion, and mathematics teachers seen as the regular reminders that in mathematics these students are a failure.

In the study, it was the students who didn't experience success in their school mathematics learning that were more likely to be negative about the subject. These participants thought that their teachers were pre-occupied with the "bright students", perhaps indicating that the teachers were struggling with the range of student abilities in the class. Conversely, some of the teachers who were remembered favourably were perceived as having had time for all their students, regardless of their mathematical ability. These teachers were seen as being focused on the students more than being focused on the subject allowing them to teach in a relational manner and hence, they were liked and appreciated and these feelings seemed to be transferred to the subject.

It was clear from the data that some of the participants saw their mathematics teachers as intelligent and gifted mathematicians, but as poor pedagogues. This perception seems to be consistent with the research findings of Picker and Berry (2000). The problem here is that the students seem to find it hard to relate to their mathematics teachers and they develop affective responses to mathematics and mathematicians based on these impersonal experiences of the subject. Indeed, preservice secondary teacher education programmes and secondary school structures have a part to play in this perception. To become a secondary school mathematics teacher, one usually completes a three-year mathematics degree, which is followed by a one-year teacher programme, therefore placing the emphasis on the mathematics (75% of the time) over the pedagogy (25% of the time). While this is not the forum to discuss this model fully, there appears to be a need for research into its implications. Also, secondary schools are structured around subject disciplines where mathematics and mathematics teachers are clearly delineated from the other subjects. Thus, in a sense, one becomes a *teacher of mathematics* rather than a *teacher of students*. Of course many mathematics teachers are good at their job, but the structure of the secondary schools may be inadvertently exacerbating a poor perception of mathematics teachers and mathematics.

*Mathematics Teacher, Mathematics Teacher, or Mathematics Teacher?*

The perception that mathematics teachers are fascinated by the subject (and the students who are good at it) but little interested in the average or struggling students could again be seen as another factor that widens that gap between teacher intentions and student experience.

Palmer (1993) commented on teachers who appear to be liked and respected by students through the metaphor of friendship, suggesting that effective teachers have and display a friendship-type relationship between themselves and their subject (in this case mathematics). Through this, “students are affirmed by the fact that this teacher wants them to know and be known by this valued friend [mathematics]” (p. 104). In this study, many of the participants acknowledged their teachers’ enthusiasm for mathematics, whether they liked the teacher or not. Clearly then, more is required than just a *friendship with mathematics*, and Palmer goes on to outline some further implications:

The teacher, who knows the subject well, must introduce it to the students in a way one would introduce a friend. The students must know why the teacher values the subject, how the subject has transformed the teacher’s life. By the same token, the teacher must value the students as potential friends, be vulnerable to the ways students may transform the teacher’s relationship with the subject as well as be transformed. If I am invited into a valued friendship between two people, I will not enter unless I feel that I am valued as well. (p. 104)

For many students it seems as if the teacher’s love and enthusiasm for mathematics is not perceived as an invitation for them to share their teachers’ passion for the subject. Again, Palmer comments:

The teacher may love the subject in a possessive way that prevents the students from entering in. The teacher may be so possessive of the subject, and of his or her relation to it, that students are required to accept the subject on the teacher’s own terms, discouraged or forbidden from assessing the subject and finding their own relation to it. Here the teacher’s enthusiasm is not an invitation but a demand. (pp. 104-105)

In this way, some mathematics teachers can so significantly influence the students’ affective responses to the subject that they see the subject as an enemy - something to be feared and avoided. This was illustrated by the description of *Mr Brock* in Chapter 6, but not all mathematics teachers were perceived this negatively. The caricature of Mr Wilson revealed a teacher who could teach with

a passion for the mathematics while inviting students to join him in his friendship with subject.

*Mr Wilson: A Passion for Students and Mathematics*

The description of Mr Wilson in the previous chapter indicated that not all the teachers recalled in the study were disliked or feared, albeit they are a minority. It seems that these teachers still had a strong commitment to mathematics but it was seen in a positive light and often described as “a passion for the subject”. What was different from the disliked teachers was their perceived humanity and relational approach to teaching, and it seems as if these personal qualities are the things that made a difference in the way the participants not only remembered their teachers, but also in how they conceived of mathematics and themselves as mathematics learners. These personal teacher qualities and characteristics appear to be critical in perceptions of mathematics and feelings about the subject, and yet they seem to be the untouchable, indefinable dimensions of teacher selection, education and appraisal (Fraser & Spiller, 2001; Hargreaves, 1998b; Palmer, 1998).

In generalising the findings of the study to secondary school teachers, two distinct influential links seem apparent. Firstly, as indicated above, the personal characteristics and qualities of the teacher seemed to be highly influential in the students’ feelings and attitudes about mathematics and themselves as learners of mathematics. In essence, if the student liked the teacher, then they liked the subject and if they didn’t like the teacher, then they didn’t like the subject. Secondly, regardless of whether they liked the teacher or not, students tended to adopt the beliefs about mathematics of the teacher. This indicates that the general perception of mathematics as infallible and absolute will continue to pervade the populous at large. The preservice teachers who participated in the study brought these beliefs, attitudes and feelings to their initial teacher education programme, and these then influenced their development as teachers of mathematics.

## **The Relationship Between Affective Views About Mathematics and Preservice Teacher Education in Mathematics Teaching and Learning**

When the participants began their initial teacher education programme, they had already formed a range of beliefs, attitudes and feelings about mathematics from their prior experiences. These experiences included, but were not limited to their own schooling. However, as outlined above, their experiences of mathematics at school, particularly secondary school, seemed to be the most significant in determining their affective views.

### *Initial Affective Views: Foundational Conceptions of What is True*

At the beginning of the study, the participants were able to articulate clearly their thoughts and views on mathematics and mathematics education. Their opinions seemed very firm and there was a sense in which the participants saw their views as being true in an absolute manner. The beliefs they had formed about mathematics and mathematics teaching and learning through their school experiences were, in many cases, paramount truths against which they would measure all other information.

The points made in the previous paragraph were evident throughout the data, but three particular cases illustrate the strength of the participants initial affective views about mathematics. In her second interview (Interview 2.6), Samantha suggested that her experiences on the course were interesting and enjoyable, but she still felt that mathematics was a dull, boring and irrelevant subject because that was what it was like for her at school. Clearly in her case, she was convinced about her feelings about mathematics, and the tertiary course in mathematics teaching and learning was largely irrelevant in persuading her otherwise. Likewise, after his practicum Brad talked about his school experiences, which were relatively poor, as being “reality” and that was just how mathematics is taught and learned. For Brad, despite considering other possibilities, truth or reality was based on his experiences as a school student himself. The third example was Marina (see Chapter 6) who referred to her initial views as “a habit

of the brain”, and unless she consciously and consistently addressed them, she would tend to revert to her foundational beliefs and attitudes formed at school.

These examples illustrate the strength of the participants’ primary beliefs, attitudes and feelings which they formed largely from their school experiences. This is consistent with the theories of Green (1971), Lortie (1975) and Rokeach (1968) who suggested that foundational affective views, which are formed through repeated experience, are difficult to change. Aware of this literature, the lecturers in the participants’ initial course in the teaching and learning of mathematics sought to deliberately address these affective issues.

#### *Initial Tertiary Course in Mathematics Education: A Season of Change*

The quantitative data clearly showed a significant change in the participant groups’ affective views about mathematics (see Chapter 4). The reasons for these changes and the nature of the reforms were then outlined through the qualitative data in Chapter 5. In short, these data revealed substantial positive movement in the beliefs, attitudes and feelings of the participants as they completed their initial teacher education course in mathematics teaching and learning.

### **Major Issue 2: Mathematics Education Course**

The second major issue to be discussed is the need for preservice teacher education to overtly address the affective domain. The findings of this study clearly showed that it is possible for an initial teacher education course in mathematics teaching and learning to make a positive difference to the beliefs, attitudes and feelings of the preservice teachers. Most of the participants started their teacher education programme with relatively negative and unhelpful affective views of mathematics, and if this is as wide-spread as the literature seems to indicate, then it behoves mathematics teacher educators to address them.

### *Moving Towards Positive Views About Mathematics*

As mentioned previously, the beliefs about mathematics at the start of the study were largely consistent with a Platonist view (Ernest, 1989), and it was noted that this view is not desirable for teachers of mathematics. During their course in the teaching and learning of mathematics, the participants were challenged about their beliefs and encouraged to analyse them critically. The data showed that indeed their views did change. While their views were more complex and eclectic during phase two, it was clear that they had moved towards a more healthy perspective of mathematics and their beliefs were generally more consistent with Ernest's (1989) Instrumental view. There were snippets in the qualitative data that suggested that some of them were moving further towards a problem-solving view (Ernest, 1989), but that would not have been the case for many of the participants.

The currently pervasive view amongst mathematics educators seems to strongly support a problem-solving perspective on mathematics as is evidenced in curriculum statements around the world (e.g., NCTM, 2000; Ministry of Education, 1992). It therefore, seems desirable for teachers of mathematics to share this perspective, and therefore, the changes evident in the participants' beliefs in the study were positive, but not as yet satisfactory. Indeed, some of their primary beliefs seemed resilient to change as indicated by their enduring view that *the basics* were the heart of mathematics and of vital importance. Furthermore, there was evidence later in the study (phase three) that many of the participants reverted in varying degrees, to their initial beliefs which had become established during their own schooling. This meant that the significant but inadequate gains of the tertiary course were further eroded. Indeed, it appears to be an ongoing and uphill task to facilitate the necessary affective change, given the strength of preservice teachers' primary initial beliefs. Nevertheless, the positive changes in the participants' beliefs, attitudes and feelings were worthwhile and worthy of investigation.



### *Factors in Positive Affective Reform*

The data collected during the second phase of the study revealed that the participants had indeed changed their beliefs, attitudes and feelings about mathematics, and the contributing factors seemed to be in two categories. The first category was a direct one related to the teaching strategies and curriculum of the course, and the second was more indirect, relating to the modelling of the teaching staff.

In the study the participants' affective views about mathematics seemed to change because they were overtly addressed as a significant, important and foundational part of their mathematics education course. These activities highlighted the issue for the participants and caused them to reveal and focus on their own affective views. Once their beliefs, attitudes and feelings were brought to the fore, then aspects of the course provided a forum for the participants to reflect upon their views and emotions and begin the process of affective change. Alongside the review of their initial affective responses, the activities were also designed to help the preservice teachers build new understandings and feelings about mathematics.

In the data, the participants highlighted some key events that they felt were critical in their affective development in mathematics. The first of these, where they had to review their own mathematical experiences as a school student through drawing, journalling and discussing, seemed to be critical in bringing to the fore emotions and attitudes about mathematics that were, for many, tacit and hidden. The recounting of these experiences was often emotional as the participants relived events that were for many unpleasant, but seemed critical to their affective development. If indeed, beliefs and feelings are developed through direct experience and held in episodic memory, then an important avenue for affective change is through key prior events, and this seemed to be the case in this study (Green, 1971; Pajares, 1992; Rokeach, 1968; Tillema, 2000).

Two other events - the field trip and the sessions on Fibonacci's Sequence, were experiences designed to facilitate the development of positive affective views

about mathematics. In the data, the participants noted these as critical events in their changing perspective of mathematics because they were fundamentally different from their previous experiences. It therefore, seems as if these experiences were the positive flip-side to the negative experiences they had as a school student. While these events were generally enjoyed by the participants, they also seemed to be important in the reform of their beliefs about mathematics. What was evident was the broader conception of mathematics as being related to the world around us and useful to solve meaningful problems. These points were addressed in the course lectures and readings, but it seems that it was their experiences that were seen as critical in their changing views. Indeed, the story of Mike (recorded in Chapter 5) highlights the critical role certain events play in the development of their perceptions and feelings about mathematics.

The participants were also able to note a number of factors that were less direct, but equally important in their affective development. These included the lecturers, the nature of the course and the class atmosphere. As with the more direct factors, these too were based in the experiences of the participants.

In the first of the major findings, the participants' school mathematics teachers were highlighted as a critical factor in their negative views of mathematics and so perhaps it is not surprising that the course lecturers were prominent in their views through the course. Indeed, the participants highlighted in the data the crucial role the lecturers played in their positively changing views. In a sense, it seemed that the course lecturers were providing a positive experience of mathematics that replaced the negative experience they had of mathematics teachers at school. This notion of replacement was evident in some of the contrasting ways the participants perceived their school teachers and their lecturers. The data indicated that the lecturers were able to operate in that space that Palmer (1998) described as the "crossroads of the personal and the professional", where they were perceived as being knowledgeable and passionate about mathematics but also able to connect with the students in meaningful ways in the context of mathematics education. Indeed, it seems as if the participants were introduced to mathematics again, but not as something to be feared and avoided but rather as an invitation to

a valuable and worthwhile friendship, which the lecturers already enjoyed with the subject and an expectation that they too could enjoy it. For a number of the participants, the experiences they had with their lecturers seemed to result in more positive affective responses to mathematics itself. They also helped many to put a human face to the subject, thus promoting a change in their beliefs, seeing that mathematics is a human activity that can be enjoyable and indeed, useful.

The changing perspective of mathematics appeared to also be facilitated by the nature of the course, which was seen as collaborative, practical and challenging. This was supported by an atmosphere that the participants described as fun, relaxed, warm and inviting. By engaging in mathematical activities that were connected to real life in cooperative situations, it appears as if the participants experienced affective dissonance as they sought to make sense of their new encounters in the light of their prior beliefs. Some of the participants expressed surprise that their thinking was really extended in a mathematical context, and yet at the same time they had fun and enjoyment. Again, this seemed to challenge some of their primary beliefs about mathematics and they now seemed to accept that mathematics can be challenging and enjoyable concurrently. Indeed, this was consistent with the findings of Jones, et al. (2000) who also found that it was possible to facilitate change in preservice teachers' affective responses to mathematics.

#### *A Theoretical Perspective on the Changes.*

The course seemed to provide opportunities for the participants to construct new conceptions of mathematics through experiences that caused both cognitive and affective dissonance. What was clear was that the participants' initial affective views about mathematics seemed firmly established, and as such they could be seen as robust schema that resisted all but substantial attempts to change (von Glasersfeld, 1995). Indeed, their views were often deeply personal and individually held. However, the participants generally had a shared or common perspective of mathematics, which was also consistent with the views of the general public (Carroll, 1994a). Thus, it appears that this view transcends the

individual and has an existence in social consciousness (Wertsh & Toma, 1992). Clearly, there is a case for understanding the development of these views through both the ‘radical’ and ‘social’ forms of constructivism. Indeed, both theories provide insight into how the issues associated with negative views of mathematics might be addressed, as there are both individual and communal dimensions to the problem.

As was plain throughout the study, the affective positions constructed by the participants through their schooling influenced their learning throughout the first year of their initial teacher education. In that sense, their prior experiences were a prime guiding influence (Boud, 1993). Consistent with the tenets of ‘learning from experience’, the prior experiences of the participants were more than just the beginning position as they begun their tertiary education. Their prior experiences were a central and significant mediating influence on their affective development throughout the study. Indeed, the tertiary course in mathematics education seemed to focus on their experiences, both prior to commencing their teacher education programme, and the activities that formed an integral part of their study. Throughout the data here, both directly and indirectly, the participants highlighted the central role of reflection in learning and developing from those experiences (Boud, et al., 1985; Mason, 1993).

The data and findings of the current study related to the participants’ development through the tertiary course in mathematics education can be meaningfully explored through the theories of radical and social constructivism and ‘learning from experience’ (Indeed, in a later section the concept of ‘situated cognition’ is also used, to explore the data from the third phase of the study). Conversely, the findings also provide support for the tenets of these models because they exemplify the generalisations the theories contain.

#### *The Fragility of the Changes*

As mentioned at the start of the discussion on this second major issue, the positive affective changes that were evident in the data were worthy of celebration, but

neither entirely adequate nor enduring. The adequacy of the participants' affective change was discussed earlier and the longitudinal nature of the study was employed to consider the long-term influence of their mathematical experiences. Three examples in the data illustrated the fragility of the positive changes the participants experienced in their beliefs attitudes and feelings about mathematics.

In discussing her attitude towards mathematics, Marina talked about her struggle with her original affective views, which were described as "old habits of the mind" (Interview 3.7). She highlighted the need to keep challenging her old views because her default perspective was rooted in her distasteful mathematical experiences of school. The implication is that affective changes takes time and it is an on-going process that requires more than just a one-off positive course experience. Furthermore, it seems as if aspects of the participants' initial teacher education programme can actually work against positive affective reform. A number of the participants expressed a measure of anxiety about a numeracy proficiency test they were required to pass before they could graduate. While this was a small and relatively insignificant part of their teacher education programme, it seemed to have a profound impact on the attitude and feelings of some of the participants. The third example was the school-based practicum, and this will be discussed in the following section.

### **Major Issue 3: The Influence of Practicum Experiences on Affective Views about Mathematics**

The quantitative and the qualitative data both indicated that the school-based practicum was a critical experience in the participants' mathematical affective development. While the participants seemed fairly homogeneous in their views at the end of their tertiary course in mathematics education, they seemed divided in the data collected during the third phase, as was clearly indicated in Figure 4.1. This seemed to show the profound influence that their school-based practicum had to either reinforce or undermine the new perspective of mathematics that they had developed through their tertiary course in mathematics education.

### *Affirming Positive Affective Change*

The participants who had mathematical experiences during their practicum that they regarded as good, generally continued to hold positive affective views about mathematics. It seemed that the practicum experiences confirmed the affective changes that arose during their course and therefore, they became more assured in their new views. The consistency between the reality of the practicum experiences and the views and knowledge developed through their course appeared to be necessary for positive mathematical affective reform in the participants.

In describing their experiences, the participants noted aspects of mathematics that were consistent with dimensions of Ernest's (1989) instrumental and problem-solving views. Again, these seemed to resonate with their mathematical encounters on the course and the repeated, consistent experiences in two different contexts led to more resilient affective views. Green (1971) suggested that primary beliefs develop through direct experience, and so it seems to have been important that these two realms of experience have coalesced towards a consistent mathematical epistemology that is more desirable. However, the sum of experience from the course and the practicum seems rather insignificant compared to the wealth of experience the participants brought with them from their own schooling. While it is positive that these participants have sustained their new perspective of mathematics through their practicum experience, it is still of concern as to whether it will be maintained long-term. Indeed there is scope for longitudinal research conducted over an extended period of time to monitor the changes in preservice teachers' affective views as they progress through the preservice and inservice teacher education. The relative instability of participants' views was particularly evident for those who perceived their mathematical experiences on practicum as negative.

### *The 'Washing-Out' of Affective Change*

For approximately half of the participants, the mathematical experiences on their school-based practicum were viewed in a less than positive light. Interestingly, almost all of these participants were placed in senior primary or intermediate

classrooms. In many respects, the experiences of these participants were similar to their recollections of their own schooling and as such it seemed to reinforce some of their beliefs and attitudes that they had prior to commencing their initial teacher education programme. Perhaps the ‘real world’ experiences in their own schooling and on practicum caused the participants to doubt the idealistic views that were developed in the artificial environment of the tertiary course. Indeed, in many respects it seems that their practicum experience did “wash-out” (Zeichner & Tabachnick, 1981) aspects of their affective development, particularly as it affirmed the views they held prior to their tertiary course in mathematics education.

The participants who perceived the practicum experience as negative often worked with classes that were streamed and taught in a routine fashion. This caused Warren (Interview 3.4) to comment that mathematics was indeed routine in nature and to conclude that students liked its ‘routineness’. Also, Sally stated that mathematics is basically boring, and while it could be made more tasteful and interesting in the idealistic context of the tertiary course, the truth about mathematics is that it is dull and only accessible and enjoyable for socially inept individuals. These participants illustrated how the practicum experience seems to have reinforced the beliefs and feelings they developed through their own mathematical education at school and, by implication, the insignificant influence of the tertiary course in mathematics teaching and learning.

#### *Affective Development during Practicum as Situated Cognition.*

As the participants undertook their school based practicum they were engaged in many of the tasks and experiences that were closely associated with their chosen career. Indeed, the data revealed that there were a number who saw their time on practicum as “real life”, as opposed to the tertiary course which was seen by a few as somewhat artificial. It seemed as if the participants saw their time in the school classroom as a form of apprenticeship where they could participate in the legitimate activities of a teacher and learn “what teaching was really about”. As

such, the preservice teachers were involved in a form of ‘legitimate peripheral participation’ (Lave & Wenger, 1991).

Through their ‘legitimate peripheral participation’ the participants were, in a sense, being enculturated into the community of teachers (Lave & Wenger, 1991). This process involved learning the values, beliefs and attitudes of the community which were often not spoken, but woven into the fabric of teaching experience in a classroom. When it came to their experiences of mathematics teaching and learning, if these affective qualities supported the ones of their tertiary course, then their beliefs and attitudes were largely confirmed. However, when the underpinning values of their practicum experience were more akin to their own school experiences, then the affective development of the tertiary course was often negated. It seemed that the authentic activities of classroom practice conveyed the affective views that were perceived as legitimate, and to this end, the preservice teachers were continuing their socialisation into the community of teaching practitioners (Jones, et al., 1999). The model of ‘situated cognition’ highlights the inadequacy of trying to address the affective issues in mathematics education through preservice teacher education alone.

#### *Long-Term Changes in Affective Views*

The influence of the school-based practicum to either reinforce or undermine the learning of the mathematics education course indicates the fragility of the participants’ affective change post schooling. Indeed, this was clearly illustrated in the cases of Brad and Marina presented in Chapter 6 where their different practicum experiences resulted in different affective views about mathematics, despite the similarity of their perspectives prior to working in the classroom. This study was limited to the first year of the participants’ initial teacher education programme, but it would have been interesting to follow them through their final two years and into their first few years as qualified teachers. It seems that for many of the participants, the positive changes in their affective views about mathematics are somewhat tenuous, and experiences either inside or beyond their



tertiary programme can quickly facilitate a return to their initial, primary beliefs formed through their own schooling.

In earlier discussion, it was suggested that tertiary teacher education courses in mathematics teaching and learning may be the key site to effect positive affective change, and indeed the data suggested that this may indeed be the case. The difference between the tertiary course and the other influencing experiences (like their own schooling and practicum) is that it is largely directed by the mathematics educators concerned whereas the other experiences may be rather arbitrary. However, the experiences during their own schooling and during practicum have the perceived authority of being 'real-world', and hence, the experiences of the tertiary course could be dismissed as being idealistic and largely irrelevant. Certainly the participants will have another course in mathematics education, but they will also have further school-based practicums and eventually they will work in a school environment, and so it is sobering to consider that perhaps the cycle of negative affective views (Ball, 1990) will continue. It at least seems imperative that mathematics educators consider how they can work alongside preservice teachers on or after practicum to help them reflect upon their unmediated mathematical experiences and discuss their developing affective views.

### **The Differences Between Starting Positive or Starting Negative**

In the quantitative data the trends and exceptions were explored, and comparisons made between the participants whose initial affective responses were either relatively positive and those that were negative. In short, the participants who were initially more positive were also relatively stable in their views whereas those who were initially more negative were relatively unstable in their views (see Table 4.2 and Figure 4.3). Furthermore, the patterns for their responses indicated that the affective views of most of the participants were more positive after their tertiary course but reverted towards their initial views after their practicum (well illustrated by the V-shaped graphs in Figure 4.3). Again, together these patterns and trends seem to support the primary and strong nature of the participants'

beliefs, attitudes and feelings developed during their “apprenticeship of observation” (Lortie, 1975) as a school student. In particular, the ambivalent group and the negative group showed an inclination to return to their initial affective views after their practicum, despite making significant positive changes during their tertiary course. It could be that the positive group’s views changed little because the course experiences were only reinforcing their already positive views, hence confirming many of their beliefs, attitudes and feelings.

In exploring the different group responses to individual questionnaire items, there were two questions (of the 25) where the results seemed to go against the trends. These indicated that the positive group supported the views that those who are good at mathematics can solve problems quickly and that mathematics is an unchanging subject (Table 4.3). While their responses to all the other questionnaire items were indicative of positive and healthy beliefs, attitudes and feelings about mathematics, these two items seem to reflect a more conservative, infallible view. It seems likely that the participants in the positive group were those who were more successful in their mathematics learning at school and so they were probably able to solve their mathematical problems quickly. Furthermore, little in their tertiary course in the teaching and learning of mathematics addressed their own mathematical competence and so they had little first-hand experience in solving mathematical problems that were challenging, and hence their primary beliefs were not disturbed. There seems to be a case for including some mathematical problem-solving experiences in preservice teacher education programmes that challenge the participants’ mathematical understanding, and consequentially confront their pre-existing beliefs.

### **The Affective Domain**

Throughout the study there has been an exploration of the participants’ mathematical affective views as they related to three particular realms of experience. In the broadest sense, the findings indicated that their affective views were closely associated with their experiences, and in particular key events or aspects of those experiences. Furthermore, the wealth of experience the

participants had as school students led them to develop primary beliefs, attitudes and feelings about mathematics that pervaded all their subsequent mathematical encounters. Unfortunately the affective responses they developed through their “apprenticeship of observation” (Lortie, 1975) seemed to be largely negative and unhealthy. Given that these beliefs and emotions seem to be crippling to many, there appears to be an urgent need for mathematicians, mathematics educators and teachers to consider, research and address the issue.

### *Changing Affective Views*

While this seems important, the study indicates that affective change is neither simple nor straight-forward. Indeed, the data suggest that it was possible to achieve significant changes in the participants’ affective views in the short-term, but the stability and sustainability of those changes seemed tenuous. This would indicate that more than a one-course intervention is necessary for permanent change to occur in their primary affective views. This study, like a number of others reported in the literature, highlights this issue but few as yet offer any possible solutions or ways forward and this appears to now be a pressing need. As mentioned previously, longitudinal research conducted over an extended period of time is required to shed more light on the issue, and while this is often difficult, there appear to be few other avenues to a more comprehensive understanding of the problem. While this study was short-term longitudinal, it wasn’t long enough to observe the long-term changing patterns in the participants’ affective views about mathematics. However, it was long enough to note that changes can be effected and lost through a couple of realms of mathematical experience.

Clearly the tertiary teacher education course in mathematics was able to facilitate some positive and significant affective change. The participants’ beliefs, attitudes and feelings about mathematics were addressed and changed by reviewing and reflecting upon their prior experiences, and by creating alternate experiences that were more consistent with a positive view of the subject. The experiences incorporated more than just details of the events, but also all the emotions, perceptions, relationships and attitudes that accompanied them. In teacher

education courses, there is scope for mathematics educators to direct the curriculum in its broadest sense, and the study suggests that through this they have the potential to positively influence the affective responses of preservice teachers. It appears that this is the least that should be done, as other influences both within and outside their teacher education programme are beyond the direct control of the mathematics educator and as such they can arbitrarily impinge upon the preservice teachers' mathematical views.

Throughout the study it was evident that there were key relationships with teachers and/or lecturers which were critical in the development of the participants' affective responses to mathematics. These have been discussed previously, but it seems that the relationships that permeate certain experiences can be the most significant factor in their emotions and beliefs about the subject, even if those relationships have largely little direct relationship to mathematics. Indeed, it seems that teachers and lecturers have the power to not only teach mathematical knowledge, but also to facilitate deep-seated affective responses to the subject, and it would appear as if those beliefs and emotions can render their content knowledge inert (Carroll, 1994a). It would seem then, if positive affective change is to occur, then it will happen in the context of thoughtful, empathetic and understanding relationships with teachers, lecturers or tutors who have both a passion for mathematics and their students (Palmer, 1998).

### **Limitations of the Study**

I acknowledge that there are a number of limitations in the study due to the nature of the sample, the relationship between the participants and myself, the methods of data collection and analysis, as well as my own personal beliefs, values and attitudes.

The participants in the study were all from a small tertiary institution that had a particular religious character. The majority of the participants were New Zealand-European and female, which probably fairly represents the community of primary school teachers, but certainly isn't representative of New Zealand society in

general. Furthermore, the sample included a disproportionate number who had been home-schooled or attended private schools. Nevertheless, it seems that the findings of the study are consistent with those of others in New Zealand (e.g., Biddulph, 1999) and when these findings are viewed together, they can be seen as more representative of preservice teachers throughout the country.

Secondly, I was also a lecturer in their initial course on the teaching of mathematics, and had a relationship with the students which was collegial, warm and friendly. The participants were aware that the data was being used for a doctoral study and therefore was to be assessed. They may have wanted to 'help me' by giving me the responses that they thought I was seeking (for example, in their responses in the interviews after their course on the teaching of mathematics). No doubt, the relationship between myself as the researcher, and the participants, also coloured my perceptions of them and their data. While this is unavoidable, I was conscious of these problems and where possible, sought to minimise them.

Thirdly, there have been some methodological issues that have limited the study. A longitudinal approach was employed to monitor and explore the participants' beliefs through a range of experiences, but it would have been beneficial to have continued the data collection for an even more extended period. The participants would have experienced a number of different things that may have had a significant impact on their affective views over the final two years of their initial teacher education programme and then into the first few years of their teaching career. Collecting data throughout these experiences would have added to our understanding of the stability of their beliefs, attitudes and feelings. Furthermore, a variety of data collection methods were employed to try and capture the richness of the participants' experiences and perceptions, but they were all primarily self-reporting. The inclusion of some data collection that involved observations of some kind may have added to the rigour of the data and perhaps, also assisted in the exploration of the participants' values which are defined as enacted beliefs (Bishop, et al., 2001). It is also likely that the data was affected by the relationship

between myself and the participants, given that I was also one of the course lecturers.

Finally, I acknowledge that my role in the study was neither neutral nor impartial. Clearly I thought there was a significant issue that was in need of exploration, otherwise I would not have chosen to research the topic. As much as one seeks to view the data in an unbiased way, it is unlikely that this was always the case. Measures were taken to minimise these issues, including engaging in an epoche process, maintaining a researcher's journal, and undertaking regular discussions with colleagues and supervisors, so the findings could fairly represent the data.

## **Summary**

Throughout the study a number of issues arose, but there seemed to be three that were most salient. The first of these was the powerful role the participants' school mathematics teachers had in their affective views about mathematics. It seemed that their primary and most consequential beliefs, attitudes and feelings were formed through their school mathematics experiences, and their mathematics teachers emerged as the most critical aspect of those experiences. The second major finding was the apparent ability of the tertiary preservice teacher education course in mathematics teaching and learning to facilitate positive and significant affective change. While these changes were not inconsequential, their long-term stability is still uncertain as was illustrated by the third major issue, that being the influence of the ensuing practicum on their new affective views. The data revealed that the school-based practicum experience had the power to reinforce or undermine their new perspective of mathematics, and in many respects these experiences were beyond the control of the tertiary institution and hence, somewhat arbitrary.

In short, the study showed that it is possible to facilitate some positive mathematical affective reform when this is overtly addressed, but these changes seem to be somewhat tenuous as preservice teachers encounter a range of

mathematical experiences that may be likely to reflect the primary beliefs, attitudes and feelings they developed as a school student.

## **Chapter 8: Conclusions and Implications**

In this chapter I first outline my conclusions of the findings of this study, then present some suggested implications of the study including recommendations for further research. Finally, I close with some personal reflections on the overall research project.

### **Conclusions**

Acknowledging the above limitations, the following major findings emerged from the data of the study:

- The participants' initial affective responses to mathematics were developed through their school experiences of mathematics, particularly at secondary school, and they were generally negative. Often there was a critical event, year and/or mathematics teacher who significantly influenced their beliefs, attitudes and feelings about mathematics. The affective views developed through their schooling seemed to be central and resistant to long-term change.
- The beliefs, attitudes and feelings of most of the participants were significantly and positively changed through their initial tertiary course in the teaching and learning of mathematics. Providing a forum for preservice teachers to recall and reflect upon their prior mathematical experiences, meant that they were able to acknowledge and begin to attend to their associated affective views. Also, many of the participants were able to build positive conceptions of mathematics through the activities and modelling of the course.
- Through their school-based practicum experience, about half of the participants remained relatively positive in their views about mathematics, and the other half reverted somewhat to the views and feelings they held prior to commencing their tertiary course in mathematics education. The participants whose views remained relatively positive had a practicum experience that reinforced the



affective views developed on the course. However, the participants whose views reverted towards their initial views had a practicum experience that was in many respects similar to their recollections of their own schooling in mathematics.

Some of the key factors in each of these major findings are outlined below.

#### *Affective Views Developed as a School Student.*

Perhaps the most significant dimension of this finding for the students was the central role the participants' secondary school mathematics teachers had on their affective development. Assuming that teachers generally don't intend to create such a negative perception of mathematics, then there is a significant gulf between the intentions of mathematics teachers and the experiences of many students. The reasons for the apparent gulf between mathematics teachers' intentions and students' mathematical experiences has not been the focus of the present study, and there is certainly a need for research into this issue. It is possible that many secondary school mathematics teachers have a conception of mathematics that is tacit, but nevertheless consistent with an absolutist and infallible perspective. Indeed, it seems likely that most of these teachers were successful learners of mathematics in this form when they were at school and university and they therefore, perpetuate the same mathematical epistemology. It seems that the cycle of beliefs noted by Ball (1990) could again be evident here. While it was not conclusive, there were some snippets in the data that hinted at these factors and I believe it is imperative that teachers, educators and researchers consider ways to explore and address this problem.

#### *Changing Affective Views Through Their Course*

Overall, the data clearly indicated that the tertiary course in the teaching and learning of mathematics was able to positively change the participants' affective responses to mathematics and this is a point worth celebrating. To achieve this, the course had to provide experiences that caused the participants to both reflect on their initial beliefs, attitudes and feelings about mathematics, and construct more healthy positive views and emotions. Given the strength and powerful

influence of the participants' initial beliefs and feelings about mathematics, then it seems imperative that their foundational beliefs are exposed, examined, reviewed and, where necessary, changed as part of their initial teacher education. Of course, this is not a simple or quick process and therefore, it may form one of the major challenges facing those who work with preservice (and inservice) teachers. Indeed, it seems as if the cycle of negative affective views about mathematics (Ball, 1990) will continue unless there is some attempt to intervene, and the current findings indicate that initial teacher education is a place to facilitate reform. Indeed, many teacher educators would probably concur that this is their mission.

#### *The Ability of Practicum to Reinforce or Undermine Affective Change*

The finding that the participants' views after their school-based practicum reverted to initial views indicates two important points. The first is the tenuous nature of the affective reform achieved through the course experiences. The views about mathematics of half of the participants reverted back towards their primary beliefs, attitudes and feelings that they established through their own schooling, indicating that the gains of the course were not resilient enough in the context of an experience that reinforced their prior views. It seems likely that most of the participants will have at least some experiences through the remainder of their initial teacher education programme that will reflect their own mathematical experiences at school and so it may be difficult for them to sustain their newly developed, more healthy views of mathematics. The second point relates to the power of the school-based practicum to reinforce or undermine their course experiences. It seems that the practicum has the power of being a *real experience* and hence relegates the experiences and learning of the tertiary course to being interesting but not applicable to the real world. These points, and others highlighted in this section, have implications for teacher educators, mathematicians and teachers, and these are now addressed.

## **Implications**

The pressing issue that was presented in the introductory chapter was the cycle of negative affective views (Ball, 1990) that pervades many people's perceptions of mathematics. While the study did offer some hope that preservice teachers can change their affective views of mathematics, in the end it did seem as if the cycle was resilient and unchangeable. However, if mathematics is to be rescued from this perpetual spiral of fear, anxiety and negativity, then it must be overtly addressed, and given the apparent success evident in the findings, teacher education can surely make a difference.

### *Implications for Teacher Education.*

At the most fundamental level, it seems important that teacher education addresses affective issues as an integral part of preservice programmes. Clearly, it is not desirable to have teachers in primary school classrooms who have negative and unhelpful mathematical beliefs, attitudes and feelings and therefore there seems to be a pressing need for intervention. If preservice teachers are to change their affective views about mathematics then it seems important that they are overtly addressed as a significant, important and foundational part of their mathematics education courses. Fundamentally, this would entail setting aside specific time for activities that provide a forum for reflection on their beliefs, attitudes and feelings. Some of the activities employed for data collection in the study such as journal writing, metaphor writing and drawing pictures may be useful to this end.

While the initial change of preservice teachers mathematical views seems to be important and to some degree achievable, the more apparent issue is the sustaining of those positive changes. The study clearly showed that experiences like the school-based practicum can 'wash-out' the positive gains of the tertiary course. In some cases pragmatic concerns seem to mean that the practicum can be an uncritical apprenticeship based on the idiosyncrasies of the associate school and teacher, so there needs to be some consideration given as to how critical reflection can be brought to bear on the experience. In particular for mathematics education,

preservice teachers need to consider not only the overt mathematics programmes they experienced, but also the underlying beliefs and values that pervade the curriculum in the classroom and the feelings and attitudes of the children and teachers concerned.

A further implication for teacher education in mathematics is the affective views of inservice teachers. While the study focussed on preservice teachers, initiating and sustaining positive mathematical reform will be difficult if the only point of intervention is with the preservice group. The study highlights the power of the school experience to shape and determine the preservice teachers' affective views about mathematics, hence if there is little change in the views of inservice teachers, then there is unlikely to be any long-term positive affective reform. This seems to me to be one of the greatest challenges facing mathematics education at present.

#### *Implications for Research*

Most of the previous studies undertaken in this area have involved one-off data collection (i.e., not been longitudinal) and have been based on self-reporting data collection techniques. These studies have been both quantitative, using Likert-scale questionnaires, and qualitative, using interviews and observations. These studies, together with anecdotal evidence and general experience suggest that a sound understanding of the problem exists in terms of the mathematical affective views of not only preservice teachers, but teachers in general, and indeed to the populous at large. In this study I have sought to build on the research of the past, and using a longitudinal approach, start to explore some of the issues around the identified problem using both qualitative and quantitative methods.

The longitudinal approach has been useful in identifying trends in the participants' affective views through a range of experiences. However, it is likely that further benefit would accrue from an even more extended study. Therefore, it is important that research is undertaken over an extended period of time so the affective responses of the preservice teachers can be monitored, documented and analysed

through the entirety of their preservice programme and even into the early years of their teaching careers. Through this sort of research, experiences and factors that influence and shape the teachers' beliefs, attitudes and feelings could be identified and would in turn inform teacher education for both preservice tertiary programmes and inservice professional development.

A distinctive feature of the study was the mixed method approach that added to the rigour of the data and gave the findings an added dimension. While there are some epistemological issues with employing these apparently disparate approaches, the benefits were evident in the triangulation of the data and the multi-faceted nature of the information. I think there is a clear implication that this mixed method approach has validity and value in the pursuit of understanding in some educational issues (Cresswell, 1997).

Another feature of the data collection exercise was the use of some different techniques such as group interviews, metaphor writing and drawing pictures. While the use of metaphors as a source of data has become more common, the use of drawings as data still seems relatively rare. However, these techniques allowed the participants to revisit their experiences and for some, facilitated the expression of their views and emotions in a forum that allowed them to be lucid and open. Furthermore, the participants seemed able to express feelings and beliefs that may not have otherwise surfaced. Through their drawings they tended to over-emphasise those particular traits that really stood out and this was useful in highlighting those factors that were perceived as critical. I am sure there are other 'creative-type' techniques that would be available and I believe there is scope for researchers to be creative in the data collection tools they employ, particularly when they are researching experience and perception.

While the data collection features outlined above were positive, there were gaps in the data due to the data collection techniques employed. Initially the study sought to investigate the participants' values alongside their beliefs, attitudes and feelings. However, values have been defined as beliefs that are enacted, and therefore they really need to be observed 'in action'. As with many studies in the

affective domain, this study only employed self-reporting techniques, and as such failed to adequately capture the values of the participants. As there have now been a number of self-reporting studies done into affective issues in mathematics education, it is important that more classroom-based research is undertaken. While this could be quite a difficult task, there is a great need to understand more about affective issues in mathematics education from sources other than individuals' written and spoken disclosures.

### **Personal Reflections on the Study**

As I grew up I was always successful in my mathematics learning and I was quite good at completing pages of exercises and timed examinations. I don't know if I really liked mathematics or if I chose it as a subject simply because I was good at it. Nevertheless, I ended up as a secondary mathematics teacher, and I think I taught mathematics pretty much the same way as I had learned it (Why not, it had always worked for me!). As I undertook further tertiary study, I began to see mathematics in a different way and started developing a different mathematical epistemology. When I began working with preservice teachers I soon realised that not all people saw mathematics and mathematics teaching and learning in the same relatively positive light as me and this led to the development of the current study.

Personally, it has always been a challenge to understand the views and feelings that many of the preservice teachers (and people in general) have held about mathematics because their experiences have been so foreign to me. This study has in a sense, forced me to listen, and listen carefully, to their stories, and in doing so I have begun to empathise with their experiences and the feelings and beliefs that ensued. Rather than seeing them with a problem they have to fix, I have realised that I am a fundamental part of the problem, because more often than not I have been the sort of person who has facilitated the events which they found so difficult and debilitating. The challenge for me is then, how can I undertake my part in mathematics education at the crossroads of the professional and the personal (Palmer, 1998)?

## **Summary**

In this study the affective views of a small group (31) of preservice teachers were explored and documented over the first year of their initial teacher education programme. The findings indicate that although they were initially negative and apprehensive about mathematics, their views largely changed for the better through their course in mathematics education. However, a number of participants reverted to their initial beliefs and feelings after their school-based practicum indicating the fragility of the changes. Throughout the study it seemed that the participants' affective responses to mathematics were largely influenced by the relationships they had with the teachers or lecturers concerned. While the findings of the study suggest that there is some hope for positive affective reform in mathematics, there are still questions about sustaining sound mathematical beliefs and positive attitudes and feelings towards the subject over the long term. I contend that this is one of the major issues facing mathematics education at the present time.

## **Appendices**

Appendix A: Previous Studies

Appendix B: Questions for the Students' Reflective Journals

Appendix C: Questionnaire

Appendix D: Interview Structure

Appendix E: Letter to Students and Informed Consent

Appendix F: Statement of Confidentiality for Transcribers

Appendix G: Letter with Interview Transcripts

Appendix H: Sheet for Participant's Comments on the Quantitative Data

Appendix I: Examples of the Drawings of the Participants' Teachers

Appendix J: Course Outline



## Appendix A: Previous Studies

AUTHOR	METHOD(S)	FOCUS OF STUDY	FINDINGS
Archer (1999)	<p><u>Participants:</u> 17 primary &amp; secondary teachers.</p> <p><u>Methods:</u> Group interviews</p>	<p>The links between teachers' beliefs and practices in teaching mathematics.</p>	<p>The most significant discrepancy between the participants' beliefs and practices was at the epistemological level (i.e., the nature of mathematics and its place in the school curriculum).</p>
Artzt (1999)	<p><u>Participants:</u> preservice secondary mathematics teachers; 2 case studies.</p> <p><u>Methodology/Methods:</u> Theorising and reflecting on the educational reflective activities of student teachers.</p>	<p>The development of a conceptual framework for reflection on teacher cognition and instructional practice.</p>	<p>The developed model can assist preservice secondary teachers in their reflection upon their pedagogical knowledge and techniques.</p>
Ball (1990)	<p><u>Participants:</u> 252 preservice primary and secondary mathematics teachers.</p> <p><u>Methodology:</u> Longitudinal qualitative.</p>	<p>The subject matter knowledge of preservice elementary and secondary mathematics teachers.</p>	<p>The mathematical understandings that the participants brought to teacher education from their prior educational experiences tended to be rule-bound and thin.</p>

	<p><u>Methods:</u> Questionnaires and interviews with a smaller sample.</p>		
Biddulph (1992)	<p><u>Participants:</u> 102 preservice primary teachers (first year). <u>Methodology:</u> Qualitative <u>Methods:</u> Open-ended questionnaire, participant log-books</p>	To investigate the effects of the participants interviewing a 5-year old student (to explore their understanding of number) on their views about teaching and learning mathematics.	The participants' beliefs about mathematics teaching and learning were challenged, although many found it difficult to shake-off traditional ideas which had become firmly embedded.
Biddulph (1999)	<p><u>Participants:</u> 242 beginning preservice teachers. <u>Methodology:</u> Qualitative <u>Methods:</u> Questionnaire (attitude), Test (competence).</p>	Preservice primary teachers attitude towards mathematics, and their level of mathematical competence	About 67% of the preservice teachers had deeply negative feelings and attitudes towards mathematics.
Bishop, FitzSimons, Seah & Clarkson (1999)	Theoretical (Proposal of intended research)	Values teaching in mathematics education.	
Bobis & Cusworth (1994 & 1997)	<p><u>Participants:</u> 93 preservice primary teachers in the third year of their B.Ed.</p>	The participants' attitude to mathematics and mathematics education through their professional	Teacher education programs can improve the attitudes of preservice teachers towards mathematics, and this shift

	<p>or Dip.Ed. graduates</p> <p><u>Methodology:</u> Longitudinal (5 years)</p> <p><u>Methods:</u> Questionnaire and some follow-up interviews, B.Ed. students' reflective journals.</p>	teacher education.	can continue well into their first year of teaching.
Buerk (1985)	<p><u>Participants:</u> Female tertiary students</p> <p><u>Methodology:</u> Informal and anecdotal</p>	Women's beliefs, values, feelings and perceptions of mathematics and strategies for remedying their misconceptions and anxieties.	Many women saw mathematics as an absolute (dualist perspective) and as an inhuman creation (infallible and complete).
Carroll (1994a, b)	<p><u>Participants:</u> 1 preservice primary teacher who struggled with mathematics.</p> <p><u>Methodology:</u> Case Study</p> <p><u>Methods:</u> Interviews (6@1hr.), questionnaire, diary, mathematics test, mathematics curriculum test.</p>	The experiences, understandings and feelings about learning mathematics of one preservice primary school teacher.	A range of affective factors influenced her ability to learn mathematics. The factors fell into 4 categories: affective, cognitive, social, and teachers' questions. Through reflection on experiences her attitude, feelings, etc. improved.
Cooney,	<u>Participants:</u> 4	The beliefs, belief	The way in which the

<p>Shealy &amp; Arvold (1998)</p>	<p>preservice secondary mathematics teachers.  <u>Methodology</u>: Case studies.  <u>Methods</u>: Survey (to select participants), 4 individual semi-structured interviews each (30-60 minutes).</p>	<p>structures and propensity for reflection of the participants over the year of their preservice education.</p>	<p>participants structured their beliefs effected the availability of those beliefs for critical review. Their school experiences were significant. A scheme for conceptualising beliefs is offered.</p>
<p>Davies &amp; Savell (2000)</p>	<p><u>Participants</u>: 53 students in Early Years Teaching degree  <u>Methodology</u>: Mixed method  <u>Methods</u>: Test on mathematical competence; responses to the prompt “For me maths is like ...”.</p>	<p>To investigate the relationship between the participants mathematical competence and qualifications, and their feelings about mathematics through the use of a metaphor.</p>	<p>The level to which mathematics had previously been studied could not be used to predict attitudes or feelings to mathematics. A high proportion of the participants began the course feeling negative about mathematics.</p>
<p>Davis (1999)</p>	<p><u>Participants</u>: 19 preservice secondary teachers.  <u>Methodology/Methods</u>: Theorising and reflecting upon class activities.</p>	<p>Exploring the participants’ views on the nature of mathematics and the role of mathematics in their lives.</p>	<p>There is great value in preservice mathematics teachers interrogating the figurative underpinnings of common understandings of mathematics and mathematics education.</p>

<p>Gondoseputro (1999)</p>	<p><u>Participants:</u> 2 inservice teachers. <u>Methodology:</u> Case studies. Interpretive using mixed methods. <u>Methods:</u> Interviews and classroom observations</p>	<p>The impact of the participants' beliefs on their instructional practices within the constraints and opportunities of the social context of teaching.</p>	<p>Teachers' beliefs have a strong influence on their instructional practices, but that actions are not always consistent with instructional beliefs.</p>
<p>Grootenboer (2000)</p>	<p><u>Participants:</u> 34 preservice primary school teachers. <u>Methodology:</u> Phenomenology <u>Method:</u> Questionnaire</p>	<p>The experiences of the participants in mathematics education in primary and secondary school, and the impact these experiences had on their beliefs, values and feelings about the subject.</p>	<p>About 33% had positive experiences in mathematics and about 67% had negative experiences. Their key factors in their experience were the teacher and success (or otherwise). Their secondary school experiences were the most powerful.</p>
<p>Gustafson &amp; Rowell (1995)</p>	<p><u>Participants:</u> 27 preservice elementary teachers in a science education course. <u>Methodology:</u> Qualitative. <u>Methods:</u> 2 questionnaires (at beginning and end of course), and semi-structured</p>	<p>The changes in the participants conceptions about teaching and learning science, and the nature of science</p>	<p>Over the 13 week course there was little change in their conceptions about teaching and learning science and the nature of science.</p>

	interviews with 8 participants).		
Gunstone & Northfield (1994)	A personal reflective review of a range of activities that the authors undertake in their lectures with preservice teachers.	The significance and importance of metacognition in the education of preservice (& inservice) teachers.	Seven principles which are fundamental to the development of metacognition and conceptual development in learning to teach.
Joram & Gabriele (1998)	<u>Participants:</u> 53 preservice elementary teachers in an introductory educational psychology course <u>Methodology:</u> Qualitative (relying on constructivist theory). <u>Methods:</u> Questionnaire at the beginning and end of the course	The changes in the participants' beliefs over a course that was designed to explicitly address their prior beliefs.	Intentionally focussing on the participants prior beliefs has a significant impact on their beliefs about teaching and learning.
Kaminski (1997)	<u>Participants:</u> 6 primary preservice teacher education students <u>Methodology:</u> Case studies (?) <u>Methods:</u> Observation of exercises followed	How do preservice teacher education students use number sense in their understanding and application of mathematical topics?	Their number sense was underdeveloped.

	by interview		
Mayers (1994)	<p><u>Participants:</u> 449 preservice primary teachers (Yr 1).</p> <p><u>Methodology:</u> Quantitative</p> <p><u>Methods:</u> Questionnaires (5-point Likert scales) prior to, and at the completion of the course.</p>	To determine whether changes could be induced in primary student teachers' beliefs about and attitudes to mathematics and mathematics teaching through their participation in a mathematics education course which adopted a constructivist framework.	The course facilitated the development of beliefs about mathematics and mathematics teaching which are consistent with constructivism and also the development of positive attitudes towards mathematics and mathematics teaching.
Mewborn (1999)	<p><u>Participants:</u> 4 preservice elementary teachers.</p> <p><u>Methodology:</u> Grounded theory, grounded interpretivism.</p> <p><u>Methods:</u> Individual interviews, group discussions, journals.</p>	To investigate the elements of mathematics teaching and learning the participants found problematic and how they resolved those problems	The participants were concerned about the classroom context, mathematical pedagogy and pupils' mathematical thinking.
Nesbitt Vacc & Bright (1999)	<p><u>Participants:</u> 34 primary preservice teacher education students.</p> <p><u>Methodology:</u> Mixed method + 2</p>	Changes in preservice teachers' beliefs about teaching and learning based on experiences in CGI.	There were significant changes in their beliefs and perceptions about mathematics across the 2 year programme based on CGI.

	<p>case studies.</p> <p><u>Methods:</u> 4 Questionnaires (Likert scales), participant journals, fieldnotes, 3 interviews</p>		
<p>Owens, Perry, Conroy, Geoghegan &amp; Howe (1998)</p>	<p><u>Participants:</u> 52 preservice primary teachers.</p> <p><u>Methodology:</u> Quantitative and qualitative.</p> <p><u>Methods:</u> Questionnaires (Likert scales) administered at the beginning and end of the semester course, student journals, interviews and observational notes.</p>	<p>The impact of social constructivist learning theory on the affective processes of the participants as they study mathematics education.</p>	<p>Significant increases in positive attitudes and beliefs about mathematics and about themselves doing mathematics.</p>
<p>Perry, Howard &amp; Tracey (1999), &amp; Tracey, Perry &amp; Howard (1998).</p>	<p><u>Participants:</u> 336 secondary mathematics teachers, and 603 primary teachers.</p> <p><u>Methodology:</u> Quantitative</p> <p><u>Methods:</u> Questionnaire (20</p>	<p>To explore the beliefs about the nature of mathematics and the learning and teaching of mathematics of mathematics teachers and head mathematics teachers.</p>	<p>The espoused beliefs about mathematics and mathematics teaching and learning can be measured and compared. There can be a difference in the espoused beliefs of classroom mathematics teachers and their curriculum leaders.</p>



	items; 3-point Likert scales) and interviews with 8 head mathematics teachers.		
Relich & Way (1992)	<u>Participants:</u> 345 preservice teachers. <u>Methodology:</u> Quantitative <u>Method:</u> 65 item questionnaire.	To explore the participants attitudes to mathematics and the teaching of mathematics. Also to investigate the relationship between anxiety and confidence as it relates to mathematics and mathematics education.	The researchers found that the evidence for mathematics anxiety as a separate construct from confidence was not convincing.
Roberts, Cretchley & Harman (1998)	<u>Participants:</u> 237 preservice early-childhood and primary teachers. <u>Methodology:</u> Quantitative. <u>Methods:</u> Questionnaires (5-point Likert scales) administered at the beginning and end of the semester course.	To measure the changes in the participant's attitude to mathematics through a unit of study on mathematics that was lectured by mathematicians.	The only significant change in the participant's attitude was a drop in their perception of the usefulness of mathematics.
Ruffell, Mason & Allen (1998)	<u>Participants:</u> Primary school students, preservice primary and	The attitude of the participants to mathematics. The concept of mathematics	Attitude is a complex construct and research about attitude is problematic.

	<p>secondary teachers and inservice primary teachers.</p> <p><u>Methodology:</u> 8 small scale quantitative studies.</p> <p><u>Methods:</u> Group interviews, individual interviews, diaries and questionnaires.</p>	<p>as a construct.</p>	
<p>Schuck (1996, 1997b &amp; 1998)</p>	<p><u>Participants:</u> 49 first year preservice primary teachers, 8 in-depth, 4 mathematics education lecturers</p> <p><u>Methodology:</u> Grounded theory</p> <p><u>Methods:</u> Paired interviewing, open-ended questionnaire, 8 in-depth interviews and 4 interviews with lecturers.</p>	<p>To explore the beliefs and attitudes of prospective primary teachers with respect to the teaching and learning of mathematics.</p>	<p>The beliefs and attitudes of preservice primary teachers are often powerful constraints on their teaching and learning in mathematics. Techniques which allowed these participants to critically reflect on these views were helpful in their development as mathematics teachers.</p>
<p>Schuck (1997a)</p>	<p><u>Participants:</u> 49 first year preservice primary teachers.</p> <p><u>Methodology:</u> Qualitative research simulation.</p>	<p>The exploration of affective aspects of learning mathematics and problematic issues in mathematics education.</p>	<p>The research activity encouraged beliefs to become explicit and hence, available for critical review as the participants considered their own teaching of</p>

	<p><u>Methods:</u></p> <p>Interviews in pairs.</p> <p>Participant reflection on the questions and responses in the interviews.</p>		<p>mathematics.</p>
Schuck & Foley (1998)	<p><u>Participants:</u> 185 preservice teachers.</p> <p><u>Methods:</u></p> <p>Questionnaires (Likert scales) administered at the beginning and end of the semester course, participant reflective journals.</p>	<p>To investigate a web-based intervention that encouraged dialogue about mathematics between an international community of mathematics educators and the prospective teachers' local learning community.</p>	<p>The intervention encouraged the participants to examine and evaluate their own beliefs about mathematics and mathematics education.</p>
Shield (1999)	<p><u>Participants:</u> One secondary mathematics teacher.</p> <p><u>Methodology:</u></p> <p>Ethnographic case study</p> <p><u>Methods:</u></p> <p>Participant observation, interviews, artefacts, research notes, surveys and questionnaires</p>	<p>To study the complex relationship between the beliefs and practices of a mathematics teacher.</p>	<p>While the participant has clear and quite strongly held beliefs about mathematics and its teaching and learning, his classroom practices didn't always reflect those beliefs.</p>
Southwell &	<p><u>Participants:</u> 75</p>	<p>The beliefs of preservice</p>	<p>There is a cycle of beliefs</p>

Khamis (1992)	preservice (yr 4 B.Ed) primary teachers; 185 primary students (Yrs 4-6); 310 secondary students (Yrs 7-10) <u>Method:</u> Survey (4-point Likert scales & some open-ended questions)	primary teachers about mathematics and themselves as teachers and learners of mathematics, and the comparison of those beliefs with those of school students	about mathematics and mathematics education which can be broken if preservice teachers are able to reflectively return to their experiences of mathematics.
Taylor (1992)	<u>Participants:</u> 12 Professors <u>Methodology:</u> Life histories <u>Methods:</u> Interviews	The development of a mathematics attitudinal model	A mathematical attitude model which incorporates attitude, thinking, feeling, acting and meta-awareness.
Tillema & Knol (1997a & b)	<u>Participants:</u> 6 teacher educators <u>Methodology/Methods:</u> Co-operative inquiry into their own practice.	To identify effective instructional arrangements for teacher education, in particular promoting belief change and conceptual change through instructional interactions.	Conceptual change teaching could have significant implications for the design of teacher education courses.
Tirosh (2000)	<u>Participants:</u> 30 female preservice elementary teachers in the second year of a 4-year teacher education programme.	To explore the participants subject-matter knowledge and pedagogical-content knowledge through a 1-year mathematics methods course.	Teacher education programmes should address issues of pedagogical-content knowledge as many are unaware of student thinking on common mathematical concepts.

	<p><u>Methodology</u></p> <p><u>Methods:</u> Questionnaire and interview.</p>		
Van Zoest, Jones & Thornton (1994)	<p><u>Participants:</u> 4 preservice elementary teachers</p> <p><u>Methodology:</u> Mixed Method</p> <p><u>Instruments:</u> Survey, interviews &amp; video analysis, fieldnotes.</p>	The impact of an intervention that promoted socio-constructivist theory on the beliefs and practices of preservice teachers in the teaching of mathematics.	The intervention group had significantly stronger socio-constructivist beliefs, although the extent to which they enacted them varied.
Way & Relich (1993)	<p><u>Participants:</u> 564 preservice teachers (85% female).</p> <p><u>Methodology:</u> Quantitative.</p> <p><u>Methods:</u> Questionnaire (20 items, 8-point Likert scales).</p>	To measure the participants self-concept in mathematics and their attitude toward the teaching of mathematics.	The participant's attitude to the teaching of mathematics improved as they progressed through their teacher education programmes, but their self-concept in mathematics remained unchanged.
Wood (2000)	<p><u>Participants:</u> Students in a 1-year post-graduate cert. in education.</p> <p><u>Methodology:</u> Phenomenonography</p> <p><u>Methods:</u> 4 Semi-structured interviews</p>	To explore the participants' understanding of, or ways of experiencing, teaching as they progressed in a 1-year initial teacher education programme.	The programme was successful in developing understanding of teaching, and it indicated factors which were influential in this process.

Wood, Cobb & Yackel (1990).	<u>Participants:</u> 1 primary teacher. <u>Methodology:</u> Case study <u>Methods:</u> Clinical interviews, video-recording and researcher fieldnotes	The changes in the participants' beliefs and practices in teaching mathematics in line with a constructivist view of learning.	The teacher made significant changes in her beliefs and practices about mathematics education in line with a constructivist view, but these did not transfer to the teaching of other subject disciplines.
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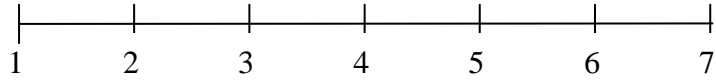
## Appendix B: Questions for the Students' Reflective Journal

1. What is mathematics?
2. Why study mathematics?
3. Describe in detail your experiences of school mathematics.
4. Describe your most vivid recollection of secondary school mathematics.
5. Outline the differences you remember between your mathematics education at primary school and high school.
6. What were your teachers' attitudes to mathematics?
7. How do you feel about mathematics?
8. What are the connections between your views about life and education in general, and mathematics education?
9. What mathematics did you use yesterday?
10. What is the difference between school mathematics and *real-life* mathematics?
11. What are the most important aspects of a child's mathematics education?
12. What things will children learn in your class besides the *mathematics curriculum*?

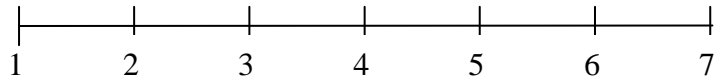




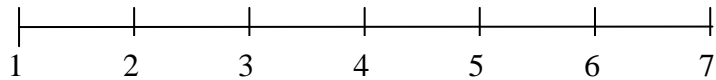
7. Mathematics is primarily concerned with arithmetic



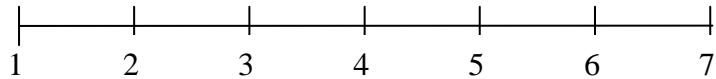
8. A person is either good or bad at mathematics.



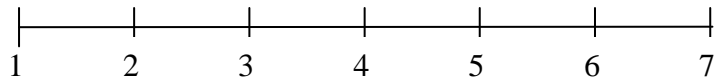
9. You don't understand mathematics, you just do it.



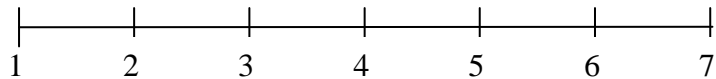
10. School mathematics can be exciting and interesting.



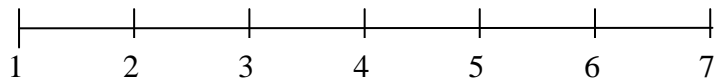
11. All students can achieve in mathematics.



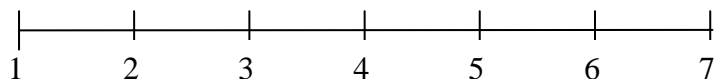
12. All students can enjoy mathematics.



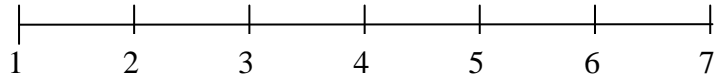
13. Mathematics is a solitary activity done in isolation.



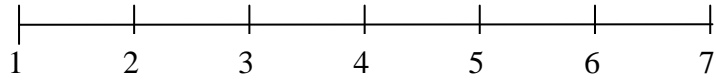
14. School mathematics has little to do with real life.



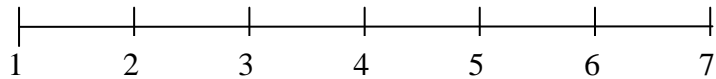
15. The advantage of mathematics is that things are either right or wrong.



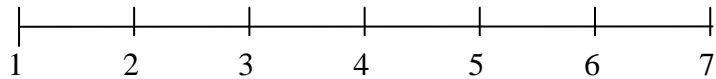
16. Mathematics is a creative and dynamic activity.



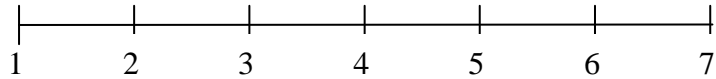
17. Mathematics involves memorising rules and applying them mechanically to solve problems.



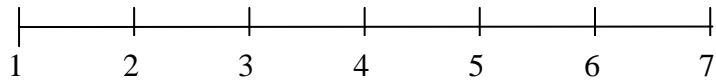
18. Mathematics education needs to “go back to the basics”.



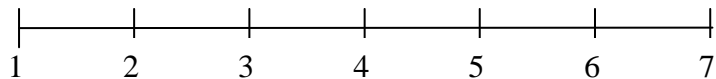
19. If you understand mathematics then you can solve problems quickly.



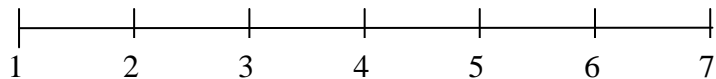
20. A good thing about mathematics is that it is an unchanging subject.



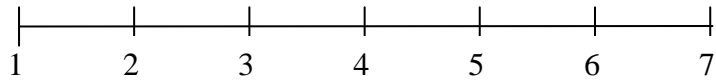
21. Students learn mathematics best through exercises and plenty of practice.



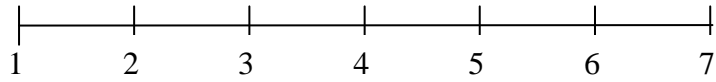
22. Mathematics is primarily about computation.



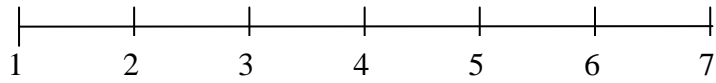
23. Mathematics education involves exploring things in the world outside school.



24. Children should use concrete materials in mathematics.



25. I feel anxious about mathematics.



Name: \_\_\_\_\_

## **Appendix D: Interview Structure**

The interviews will be semi-structured and therefore the structure is only seen as a guide. The questions listed below will be used to open up dialogue on the topic, and prompts will be used to follow-up the participants responses.

- What were your mathematics classes like [during the period of interest]?
- What did you do during your mathematics experiences?
- How do you feel about your mathematical experiences?
- Is mathematics important? Why? Why not?
- What do you think that mathematics involves?

## **Appendix E: Letter to Students and Informed Consent**

March 2001

### The Beliefs, Values and Feelings about Mathematics Project

Dear student,

This letter is to request your assistance with my research project towards a Doctor of Education degree. I am interested in the experiences preservice primary school teachers have had of mathematics, particularly in their education. Also, I am interested in how these experiences impact the student teachers' beliefs, values and feelings about mathematics and their teaching of mathematics.

I plan to start the data gathering this year, and therefore this letter is to request your involvement. I will be interested in knowing about your experiences of mathematics, and understanding your views, opinions, beliefs and feelings about mathematics and mathematics education.

If you choose to participate in this research project, then it will involve a number of data collection activities. Some of these will be activities and tasks that are an integral part of your year 1 course: *The Teaching of Mathematics 1*, while others will be outside of the course programme. Within the course you will be asked to maintain a journal and do some tasks that look back at your own mathematics education, and if you so choose, this information would be available to me for the research project. Outside of the course your participation would entail three group interviews of about 60 minutes spread over the year, and the completion of three short questionnaires at the same time. These interviews would be audiotaped and transcribed, then returned to you for correcting, deleting and editing. A professional typist who will sign a statement of confidentiality may do the transcription and you will be informed of the name of that person at our interviews.

**Your participation, or otherwise will have no impact on your assessment and progress as a student at B.I.E.** The data collected for the research project will be confidential to myself and my supervisors at the University of Waikato. All data will be coded so your name is not used, and when reporting from the project pseudonyms will be used to maintain your anonymity. The data will be stored in a secure place and then destroyed at the conclusion of the project. I will not be involved in assessing any of your work for this course, and the insights you share with me will not be available to any other staff members of the Institute.

Thank you for your time and consideration to be a participant. I look forward to sharing this journey with you.

Peter Grootenboer

[p-grootenboer@bethlehem.ac.nz](mailto:p-grootenboer@bethlehem.ac.nz)

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### **Informed Consent**

I \_\_\_\_\_ (name) consent to participating in Peter Grootenboer's study "Beliefs, values and feelings about mathematics". I understand that the purpose of the study is to explore the impact of experience on the beliefs, values and feelings of preservice primary school teachers towards mathematics. I realise that I have the right to withdraw at any stage. I am aware that information held about me will be kept confidentially and my identity not disclosed.

Signed: \_\_\_\_\_

Date: \_\_\_\_\_

## Appendix F: Statement of Confidentiality for Transcribers

*Peter Grootenboer*

*8 Portland Street*

*Tauranga*

*544 6229*

*p-grootenboer@bethlehem.ac.nz*

### STATEMENT OF CONFIDENTIALITY FOR TRANSCRIBERS

Please read this document carefully, fill in the information in the spaces provided and indicate your consent by signing at the end in the space provided.

I \_\_\_\_\_ (PRINT NAME) of  
\_\_\_\_\_

\_\_\_\_\_ (ADDRESS) \_\_\_\_\_ (TELEPHONE NUMBER) do

consent to transcribing from audiotape to computer disk the contents of tapes of interviews supplied to me by Peter Grootenboer. I consent that all the information I hear on the tape will remain confidential and I will not discuss these contents with anyone. I consent to having my name released to the people whose taped interview I am transcribing.

\_\_\_\_\_ (Signature)

\_\_\_\_\_ (Date)

## Appendix G: Letter with Interview Transcript

*Peter Grootenboer*

*8 Portland Street,*

*Tauranga*

*544 6229*

[p-grootenboer@bethlehem.ac.nz](mailto:p-grootenboer@bethlehem.ac.nz)

(Date)

Dear (Name),

I have enclosed the transcript produced from your interview with me on (date) as part of my doctoral study. I/(name of typist) did the transcribing from the audiotapes produced at the interview. I then listened to the tape and underlined in red parts of the dialogue where the names of places and people are mentioned in the interview. If any of these sections are used in the thesis, they will be replaced by pseudonyms. The enclosed version of the transcript maintains the natural rhythm of speech used in the interview. Please remember that your transcript is *raw data* and only short excerpts will be used in the thesis or papers and presentations generated from the thesis.

I would like you to read your transcript. If you have no changes please complete and sign the attached form and return this form to me. If you have made any changes or suggestions, please write them onto the transcript and return it to me for re-editing. I will make your suggested corrections and return the re-edited version of the transcript to you.

I appreciated the time we spent discussing your mathematical experiences and I thank you for your assistance. The tapes from the interviews will not be copied and they will be securely stored for five years after I finish my thesis. This is in keeping with the University of Waikato's regulations. At that time the tapes will be destroyed.

Thank you again for your cooperation.

Respectfully,

Peter



**PLEASE RETURN THIS FORM AS SOON AS POSSIBLE**

(Date)

Dear Peter

I have received the edited transcript of my interview.

Please tick one box below:

- My transcript can be used as raw data provided that the conditions of the original *Informed Consent Form* are met.
- I would like you to make changes to the transcript as indicated on the enclosed corrected version.

I would like the following pseudonym to be used when reporting from the project:

\_\_\_\_\_

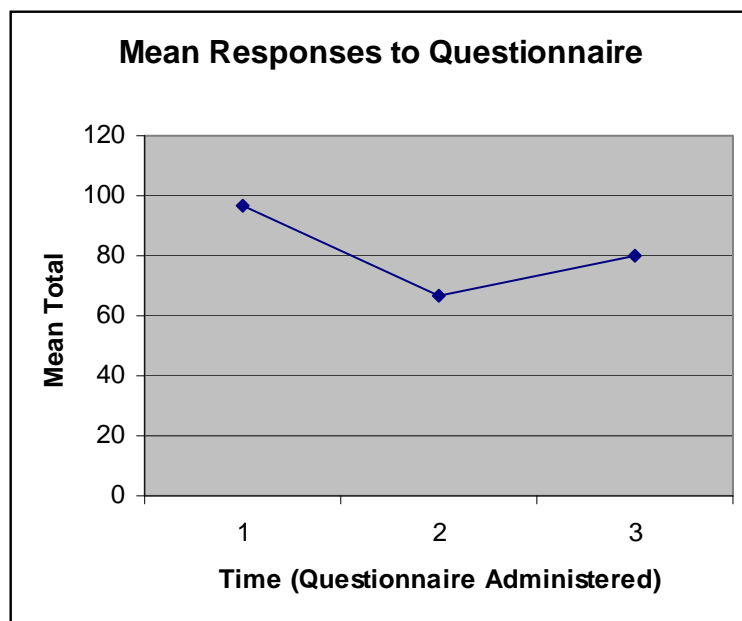
**Real Name:** \_\_\_\_\_

**Signature:** \_\_\_\_\_

**Date:** \_\_\_\_\_

## Appendix H: Sheet for Participants' Comments on Quantitative Data

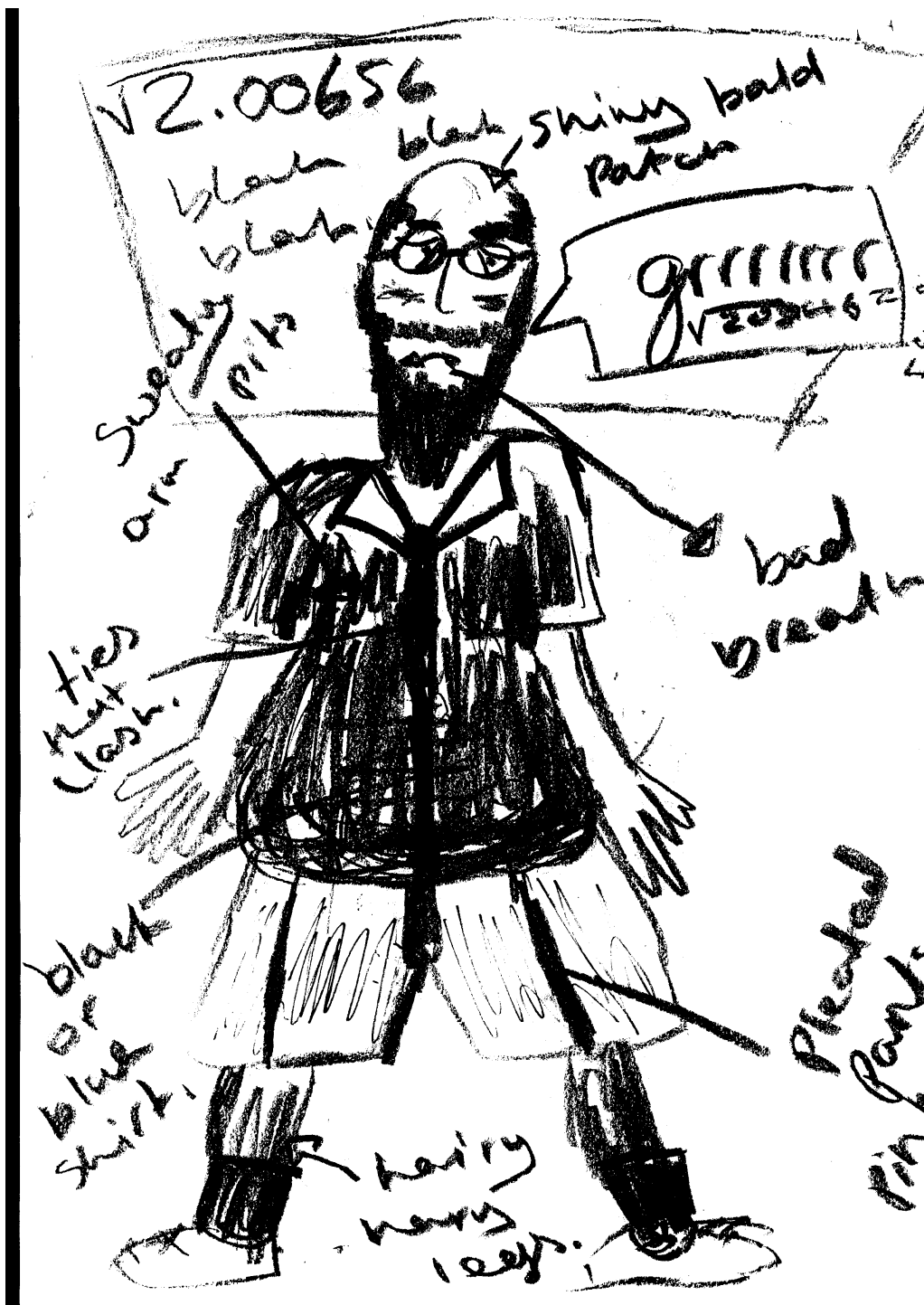
6 June 2002



Last year you completed a questionnaire about your views of mathematics on three occasions. I have collated the results from those questions and displayed the results in the graph above. **Time 1** refers to your views after your school experiences, **Time 2** refers to your views after your course in the teaching of mathematics, and **Time 3** refers to your views after your practicum. The higher values indicate a more negative view of mathematics and mathematics education. Therefore, the results indicate that initially your views were quite negative, then they were more positive after the course on mathematics education, but after the practicum they move back towards being negative, although not back as far as they were initially.

Can your comment on the data presented above. Highlight any factors you think may have influenced the pattern and possible reasons or klunens as to why it may have occurred. (If you need more space then use the back)

Appendix I: Examples of the Drawings of the Participants'  
Teachers



Don't ask for  
the answer - I don't know.



Me Let  
out of  
the  
cupboard

WITCH

OLD BAG

4x2-4x4

4x6

BLAH BLAH  
BLAH





## **Appendix J: Course Outline**

BETHLEHEM INSTITUTE OF EDUCATION

Te Wānanga Akoranga O Peterehema

### **BACHELOR OF EDUCATION (TEACHING)**

**COURSE TITLE:** TCS 5152 The Teaching Of Mathematics 1

**CREDITS:** 10 Credit Points

**PRE-REQUISITES:** Nil

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### **RATIONALE**

All teachers need to be able to plan curriculum activities and learning experiences in mathematics. Not only this, but the development of numerical and spatial understanding and skills occurs across the curriculum, articulated in the essential skills of the *New Zealand Curriculum Framework*. For many student teachers the ability to competently and confidently teach mathematics is paralleled by the need to overcome the negative experiences of learning mathematics and understand the concepts, content, attitudes and skills for the first time. This course is supported by the learning support course which, having diagnostically assessed students knowledge of mathematics, seeks to develop the students own understanding of mathematics.

This course in the teaching of mathematics begins with a consideration of the foundations to the teaching of mathematics. This includes an appreciation of a Christian perspective on the nature of mathematics and the need to learn mathematics through to an awareness of the changes in mathematics education over the last fifteen years. These changes include the shift towards context-based, problem solving approaches to mathematics learning that enable children to learn and apply their skills and understanding in real and meaningful settings. By far the biggest module, module 2 explores the learning of mathematics. In this module, students understanding of *Mathematics in the New Zealand Curriculum* are built through a study of the teaching and learning approaches to many strands of the curriculum. These topics may include number & numeration, operations, decimals & integers, geometry, measurement, probability & statistics. In addition, this module considers the resources available for the teaching of this content as well as the use of games to support learning.

## **COURSE AIMS**

This course aims to achieve three broad goals:

1. To examine the foundations of teaching and learning mathematics from a Christian perspective amidst the recent curriculum changes and research on effective mathematics teaching.
2. To develop an initial grasp of some approaches to teaching and learning mathematics, particularly in the context of the national curriculum document.
3. To become familiar with a range of strategies and resources for supporting the learning of mathematics.

## **COURSE OBJECTIVES**

### ***MODULE 1: FOUNDATIONS***

1. Critically evaluate the experiences they have had in mathematics education.
2. Explore the relationship between God, His creation, and mathematics.
3. Discuss the need for mathematics education and what it should entail.

### ***MODULE 2: THE LEARNING OF MATHEMATICS***

4. Discuss the need for mathematics learning to be structured from concrete to abstract experiences during which children are actively participating in their own learning.
5. Identify the place of the *Mathematics in the New Zealand Curriculum* in relation to the other essential learning areas of the *New Zealand Curriculum Framework*.
6. Summarise the nature of the strands within the curriculum as well as the various content topics within each strand.
7. Develop an understanding of, and an approach to teaching, some of the following curriculum content areas:
  - a. Number, numeration and place value.
  - b. Mathematical operations.
  - c. Geometry
  - d. Measurement



8. Appraise the usefulness and applicability of mathematical equipment and resources.
9. Trial and review a wide variety of rich mathematical learning activities which integrate a range of stands from the national curriculum.
10. Construct a rationale for the use of games to support the learning of mathematics.
11. Make an original game for the purpose of supporting the learning of a mathematical concept, trialling and evaluating this game with a group of children.

## ASSESSMENT TASKS

This course is internally assessed by three equally weighted tasks as follows:

### *Assessment Task 1: Essay*

**Due Date: Wednesday 28 March 2001, 5.00pm**

*Our own attitude towards mathematics is reflected in the kind of experiences we have had in mathematics learning situations, and the role we see mathematics playing in our lives. If we want our children to enjoy and have success in its learning, we need to radiate a positive, expectation of success for children in our teaching of Mathematics.*

**Comment** on this statement, **outlining** the ways in which you consider the teaching of mathematics can be made exciting and interesting. **Use examples** from your own experiences of mathematics education at school.

### **Your essay will be graded using the following criteria:**

Response to, and coverage of the topic

- (a) Develops a wide range of ideas and responds appreciatively to the topic
- (b) Develops a range of ideas and responds to the topic
- (c) Develops some ideas and begins to respond to the topic
- (d) Develops some points
- (e) Makes some points

Adequacy and accuracy of the evidence

- (a) Integrates a wide range of detailed evidence
- (b) Uses a range of detailed and relevant evidence
- (c) Begins to use relevant evidence
- (d) Presents some relevant evidence
- (e) Attempts to present some relevant evidence

Development of a reasoned argument

- (a) Develops and sustains a pointed argument
- (b) Develops a sound argument and attempts to sustain it
- (c) Begins to develop a straightforward argument
- (d) Attempts to develop an argument

Originality and independence of thought

- (a) Displays independent thought and insight
- (b) Shows some independent thought
- (c) Begins to use basic ideas
- (d) Presents a few ideas derived from class sessions

Presentation and mechanics

- (a) Accurately uses the conventions of presentation and mechanics
- (b) Generally uses accurately the conventions of presentations and mechanics
- (c) Uses the basic conventions of presentation and mechanics
- (d) Begins to use the conventions of presentation and mechanics

**Assessment Task 2: Games to support Mathematics Learning**

**Due Date: Monday 18 June 2001, 5.00pm**

Games can be a useful learning tool in mathematics. You are required to construct three (3) original games for use with young children. Specifically, you are to **construct:**

- ONE board game,
- ONE card games, and
- ONE Manipulative Activity Tasks.

**Your games will be graded using the following criteria:**

- (a) Presentation: colourful, durable, appealing to children.
- (b) Cooperative: do the children need to work together.
- (c) Instructions: clear and precise, easily understood by children.
- (d) Mathematical Content: significant mathematical learning involved.
- (e) Appropriate Level.

**Assessment Task 3: Examination**

**Due Date: Wednesday 27 June 2001, 8.30am**

A 2 hour examination covering various aspects of the course

**PLEASE NOTE: For satisfactory completion of this course, all assessment tasks must be completed to a passing grade. In the event that you are unable to meet an assignment deadline, please see your course lecturer for an extension in the week before the assignment is due. Attendance at all sessions is expected.**

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**TCS 5152: THE TEACHING OF MATHEMATICS 1**  
**SCHEDULE OF LECTURES**  
**SEMESTER 1, 2001**

SESSION	DATE	TOPIC
1	Mon 19/2	Introduction
2	Wed 21/2	Experiences of mathematics education
3	Mon 26/2	The mathematics teacher
4	Wed 28/2	What is mathematics?
	Mon 5/3	No Class
	Wed 7/3	No Class
5 & 6	Thu 8/3	Field trip (all morning double session)
7	Mon 12/3	Why study mathematics?
8	Wed 14/3	A Christian perspective of mathematics
9	Mon 19/3	Fibonnaci Sequence
10	Wed 21/3	The Golden Section
11	Mon 26/3	Introduction to numeracy
12	Wed 28/3	Numbers and place value
13	Mon 2/4	Numbers and basic facts
14	Wed 4/4	Preparation of practicum
15	Mon 21/5	Review of practicum experiences
16	Wed 22/5	Introduction to MiNZC
18	Mon 28/5	MiNZC
19	Wed 30/5	MiNZC
20	Wed 6/6	Games to support mathematical learning
21	Mon 11/6	Games to support mathematical learning
22	Wed 13/6	Measurement
23	Mon 18/6	Geometry
24	Wed 20/6	Review & Evaluation
25	Wed 27/6	EXAMINATION (8:30am)

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