

**AFFECT AND IDENTITY: THE  
MATHEMATICAL JOURNEYS OF  
ADOLESCENTS**

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# Abstract

This research captured the mathematical journeys of 31 New Zealand students over two years of their adolescence. The research framework combined a conceptualisation of identities with the notion in the affective domain of a student having a mathematical core. Specifically, this research sought to discover the nature of students' relationships with mathematics and the role of affect and identities. It further investigated how these relationships were associated with students' mathematical learning and how they changed over time. A qualitative research methodology with length, breadth and depth was employed that combined aspects of ethnography and grounded theory. Interviews and student questionnaires were the main tools used to collect students' perspectives about mathematics. Classroom observations, assessment results, school documents, parent questionnaires, teacher feedback, documented student history, reports, and prizes were also used.

Students were found to have complex and dynamic relationships with mathematics. The components of these relationships were the students' views of mathematics, their mathematical knowledge, and their feelings, identities and habits of engagement. These components were both individual and shared by the classroom community. When students engaged in mathematics, they were situated in a unique context of the moment. Each student interpreted this context individually and, negotiating with the components of their relationship with mathematics, they engaged in the mathematical task in different ways. This engagement contributed to the students' individual experiences and performances. The meaning the students derived from these experiences reinforced or altered components of their relationship with mathematics.

The students' journeys were journeys of change and negotiation and shaped by the broader context of their lives. Many of the students had become more negative about mathematics since leaving primary school. They considered it to be a unique subject because of its nature, difficulty, the routines of the mathematics classroom, and the boredom these routines generated. All of the students experienced tension balancing their social and academic needs. Furthermore, the students' ability to achieve their expectations changed as they engaged in mathematics in different ways. These factors were associated with the students' decisions about future participation in mathematics. In Year 12, when the students were aged around 16, more than half of the class chose not to continue participating in the academic stream of

mathematics, thus restricting their future choices. Six of the students were no longer participating in mathematics at any level.

The students who were thriving mathematically were those who enjoyed mathematics, viewed mathematics as an important life skill, felt confident in their ability, had highly developed engagement skills, sought relational understanding, and had multiple motivational factors. The majority of the students were not thriving mathematically. They did not feel confident in their ability, had ineffective engagement skills, sought instrumental understanding, disliked mathematics, were not convinced of its importance, and had tenuous motivational factors. The continued participation of these students in mathematics was vulnerable.

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# Glossary of New Zealand terms

- NCEA** The National Certificate of Educational Achievement is the main qualification for secondary students in New Zealand. Students work towards this certificate when they are aged around 15 years. They gain credits from both externally and internally assessed standards. Section 1.1 contains more information about NCEA.
- PAT** The Progressive Achievement Test of Mathematics was developed for New Zealand schools. This multiple-choice test covers a range of curriculum topics and skills, and is designed to compare individual students' achievement with other students in the same class and age in New Zealand. Section 4.2 describes this test further.
- Decile** The decile is a rating scale from 1 to 10. It indicates the extent to which the school draws its students from low socio-economic communities (Ministry of Education, 2010a). Section 4.2 describes this further.

# Published Work

Ingram, N. (2009), Engagement in the mathematics classroom, In M. Tzekaki, M. Kaldrimidou, & H. Sakonidis (Eds.), *In Search of Theories in Mathematics Education: Proceedings of the 33<sup>rd</sup> Conference of the International Group for the Psychology of Mathematics Education* (Vol 2, pp. 233-240). Thessaloniki, Greece: PME

Grootenboer, P., Lomas, G., Ingram, N. (2008) The affective domain and mathematics education. In H. Forgasz, A. Barkatsas, A. Bishop, B. Clarke, S. Keast, W.T. Seah & P. Sullivan (Eds.), *Research in Mathematics Education in Australasia*, p. 255-269, Rotterdam, The Netherlands: Sense Publishers

Ingram, N. (2008). Who a student sits near to in maths: Tension between social and mathematical identities. In M. Goos, R. Brown & K. Makar (Eds.), *Navigating currents and charting directions* (Proceedings of the 31<sup>st</sup> Annual Conference of the Mathematics Education Research Group of Australasia, Brisbane, Vol. 1, pp 281-286)., Brisbane: MERGA

Ingram, N. (2007). A story of a student fulfilling a role in the mathematics classroom. In J. Watson & K. Beswick (Eds.), *Mathematics: Essential research, essential practice* (Proceedings of the 30<sup>th</sup> Annual Conference of the Mathematics Education Research Group of Australasia, Tasmania, Vol. 1, pp.450-459). Adelaide: MERGA



# CHAPTER ONE: Introduction

This thesis is about a group of students who are on unique journeys through adolescence. The relationships they have with mathematics form part of each journey and it is these mathematical journeys that are the focus of this research. A *journey* is the process of travelling from one place to another (journey, n.d.). Therefore, a *mathematical journey* could be said to be a student's dynamic relationship with mathematics over time. A student's *relationship with mathematics* can be thought of as the dynamic connections between the student and the subject of mathematics – a definition that is developed in this thesis (sections 3.3 and 6.4).

Some students view mathematics as a significant component of their lives. Their journey with mathematics is a battle to be defensively fought, or an enjoyable jaunt that they expect will be continued throughout their lives. For many of the students however, mathematics remains in the classroom as an object to be left as they found it, participated in to some extent and then discarded. For them, mathematics is part of the itinerary dictated by school, parental or career requirements. It is an element of their journey to be transited quickly.

The study of adolescents' mathematical journeys is imperative. This chapter outlines how mathematics is deemed to be an important subject of study by society and the school community in New Zealand, where this research takes place. It will discuss how, despite this, there is a perennial issue in mathematics education of poor student participation and a prevalence of negative affective responses towards the subject. These issues, together with what I have experienced in my own mathematical journey, form the rationale for this thesis. The chapter begins with explaining some of the context of school mathematics in New Zealand. It then discusses the rationale for the thesis. The specific research questions and the organisation of the thesis are then outlined.

## 1.1 Schooling in New Zealand

Education is compulsory in New Zealand for children between the ages of five and 16 and is divided into primary, intermediate, and secondary schooling. The academic year goes from February to December and there are four terms. Students have around twelve weeks holiday per year. Most schools in New Zealand are funded by the government and managed within a

national framework of regulation and guidance (Ministry of Education, 2010c). The New Zealand Curriculum Framework is the foundation for learning programmes in schools. The framework specifies essential areas of learning, of which mathematics is one. It also specifies eight groupings of essential skills to be developed by all students across all subjects: communication skills, numeracy skills, information skills, problem solving skills, self management and competitive skills, social and cooperative skills, physical skills, and work and study skills (Ministry of Education, 1993).

The mathematics curriculum provides the basis for mathematics programmes in schools. This curriculum document dictates what mathematical content should be taught in schools and, to a certain extent, how it is taught. In November 2007, the Ministry of Education launched a new curriculum. However, during the research period, from 2006-2007, Mathematics in the New Zealand Curriculum (Ministry of Education, 1992) was used and it is this curriculum that is referred to in this thesis. It included a mathematical processes strand, made up of three skills (problem solving, reasoning, and communicating mathematical ideas). These were to be learned and assessed within the context of the more specific knowledge and content areas of number, measurement, geometry, algebra, and statistics. Therefore, the mathematical processes strand was woven into the other content strands. Mathematics in the New Zealand classroom has much in common with international approaches to teaching mathematics. The cultural and social norms of New Zealand, and, more specifically, the governing of school mathematics and the school community also influence the way mathematics is taught in schools (Averill, 2009).

The main qualification for secondary students, the National Certificate of Educational Achievement (NCEA) also influences the way mathematics is taught in New Zealand. Rather than a norm-referenced approach, where students are compared with each other, NCEA standards are assessed using a mastery or criterion-referenced approach. The students gain an NCEA qualification by building up credits awarded for internal and external assessments relating to topic-specific standards. Students gain credits for reaching a particular standard, rather than for how far their work is above the standard. Students enrol in standards at Levels One, Two, or Three. Although most students enrol for Level One standards in Year 11, enrolment in Level Two and Three standards in subsequent years depend on a student's choices, results and their school's individual set-up. A mathematics course generally consists of the students' learning and being assessed on the content of several standards at the same level. The Year 11 mathematics course the students' of this research participated in, for

example, had eight standards with a total of 24 available credits. Each standard is worth between two and four credits, and are awarded with Achieved, Merit, or Excellence grades. When a student has achieved 80 credits from Level One or higher, they gain NCEA Level One (New Zealand Qualifications Authority, 2008). NCEA Level Two and Three are gained from achieving credits at higher levels.

## 1.2 The importance of studying mathematics

Mathematics is considered a core subject in schools, and the mathematics curriculum specifies explicitly the importance of learning mathematics.

Mathematical understanding and skills contribute to people's sense of self-worth and ability to control aspects of their lives. Everyone needs to develop mathematical concepts and skills to help them understand and play a responsible role in our democratic society. ... 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 personal achievement, and to encourage a continuing and creative interest in mathematics;
- ...
- Help students to achieve the mathematical and statistical literacy needed in a society which is technologically oriented and information rich (Ministry of Education, 1992, p. 7).

As in many countries, outside of the school community, mathematics is considered to be an important subject of study by politicians, the corporate sector, parents, and the general public because of its perceived usefulness in our technologically-rich society and its consequent value as a critical filter to a wide variety of education and career opportunities (Anthony & Walshaw, 2007; Leder, Pehkonen, & Törner, 2002; Ma, 2001). To take part in, and contribute to society, it is therefore crucial that students participate in mathematics as a subject as part of their education. Society's perceptions of mathematics have a major influence on school mathematics curriculum, teaching, and research which, in turn, influences the way that students view mathematics and its role in the world (Dossey, 1992).

### 1.3 Participation in mathematics

A significant problem in mathematics education is that, despite the importance placed on the subject and the social and individual consequences of non-participation, many students do not choose to study mathematics to an advanced level (Boaler & Greeno, 2000; Boaler, Wiliam, & Zevenbergen, 2000b; Ma, 2001; Middleton, Lesh, & Heger, 2003). At a university level, in many countries there has been an overall decline in the number of mathematics enrolments and mathematics graduates. In Singapore, the number of bachelor graduates with mathematics degrees has declined since the mid-90s and in the United States the number of bachelor graduates in mathematics in proportion to other disciplines has, until very recently, been in an overall decline since the 1960s (Holton, Muller, Oikkonen, Sanchez Valenzuela, & Zizhao, 2009). Holton et al. (2009) suggested possible reasons for changes in these statistics such as central government decisions, decisions made at a university department level, changes in teaching style, the view that “mathematics is not seen as a path to a good job” (p. 9). In New Zealand, as in other countries, it is difficult to measure changes in university enrolments because of the differing definitions of a mathematics course or field of study. What is clear in New Zealand is that, in recent years, only a small percentage of students are choosing to pursue advanced mathematics. Using data from the Ministry of Education (2010b), in the years 2002-2007, the number of New Zealand students enrolling in mathematics as a field of study has been around 15% of total enrolments. At a masters and PhD level, enrolments in mathematics are only around 2% of total enrolments. University students are not choosing to pursue mathematics to an advanced level, compared to other domains.

Much of the filtering of capable students occurs before students reach first-year university (Ma, 2001). In New Zealand, mathematics is usually a compulsory subject until the end of Year 11 when students are aged around 16 years. A particularly critical point in the student’s mathematical journey is when the subject is no longer compulsory at school, and many students simply do not choose to take mathematics as an optional subject (Leder et al., 2002). Understanding adolescents’ mathematics journeys is therefore vital because it is during this time that they are on the “brink of deciding whether to pursue mathematical studies at post-compulsory levels” (Nardi & Steward, 2003, p. 346), and it is during this time that they tend to drift away from mathematics (Leder et al., 2002).

In New Zealand, the change to the NCEA qualification system in 2003 made it difficult to track participation in mathematics courses and compare this participation with other subjects.

NCEA data is reported by the number of enrolments in each standard (New Zealand Qualifications Authority, 2010). In 2008, students enrolled in 2,690,982 standards at Level One. Consistent with the previous four years 2004-2007, the number of enrolments in mathematics standards made up 27% of these total enrolments. Most students would take six standards in mathematics in Year 11. In the same year, students enrolled in 881,508 standards at Level Three – about one third of the number of Level One standards. Only 18% of those entries were for mathematics, a substantial difference from the proportion of Level One mathematics standards. This could show a change in the number of enrolments in mathematics standards when mathematics is no longer compulsory, but it is difficult to know if these figures are accurate because of the difficulties in comparisons. There are a different number of standards available for each subject and at each level, and there are often more choices of standards from a wide variety of subjects as students move through the school.

Similar to the university level, choosing not to pursue mathematics at secondary school is often attributed to the perceived cognitive difficulty of the subject (e.g., Miller & Mitchell, 1994). Boaler and Greeno (2000) instead posed the view that students reject mathematics because of the culture and routines of advanced mathematics classrooms (p. 171). In a case study of one New Zealand girl, Shannon (2004) found that there were cultural factors within the classroom which led the student to choose another subject over mathematics. The student viewed mathematics to lack social relevance, and the voices of others helped guide her decision to no longer participate in mathematics. Ma (2001) viewed students' participation as multifaceted, and described mathematics participation as a complex decision made in a social environment. Many sociological and psychological factors, such as parental involvement, expectations of success, peer influence, school environment and family socio-economic status interacted and contributed to this decision. Similarly to other researchers (e.g., Norton & Irvin, 2007), Ma (2001) linked students' declining participation in mathematics to the affective domain.

Affective rather than cognitive problems of students contribute to mathematics dropout in the later grades – students do not drop out ... because they lack the cognitive abilities required for further mathematics courses but because they do not desire to take further mathematics courses (Ma, 2001, p. 228).

This thesis focuses on this affective domain to seek understanding of how affect might relate to students' mathematical journeys and their participation in mathematics.

## 1.4 Affect and mathematics

Society values mathematics as an important subject (section 1.2), yet many people have negative feelings about their own relationship with mathematics. Learning mathematics is an emotional practice and exposure to the subject generates a range of affective responses in students. *Affect* describes the experience of feelings and emotions (McLeod, 1992). Students may feel happy and full of anticipation about a particular problem, they may feel full of interest about the context of the problem or how it might turn out, and may feel satisfaction at the conclusion of the problem. Nevertheless, students' affective responses to mathematics are often negative. Many students feel *anxiety* while doing mathematics lessons – a relatively intense, negative reaction to what they are doing (Hendel & Davis, 1978). They feel frustration and despair during attempts to solve a problem, and feel jealousy when they perceive people around them can solve it easily. Indeed, many students do not enjoy the subject (Evans, 2000). Understanding why so many students feel negatively about mathematics and understanding their feelings about mathematics compared to other subjects is important. Furthermore, students seem to become less resilient to negative emotions and feelings about mathematics as they move through school (McLeod, 1992). This change is thought to play a role in students' choices to study mathematics when it is not compulsory (McLeod, 1994). It is important to capture this process of change by conducting research in mathematics classrooms over a period of time to understand its effect on the students' learning of mathematics (Leder & Grootenboer, 2005b).

Many people avoid negative feelings by not engaging in mathematics (Greenwood, 1984). In this thesis, *engagement* is seen as a student's involvement in the mathematical activity of the classroom and their commitment to learning the mathematical content (discussed in section 5.1). Others are helpless when dealing with numbers, admiring those who “perform even arithmetic without pain” (Mandler, 1989, p. 7). There are innumerable examples in society of this. For example, Stephen Hawking wrote in the acknowledgements of his book "A Brief History of Time."

Someone told me that each equation I included in the book would halve the sales  
(Hawking, 1998, p. iv).

One of the influences (Ell, 2001) on the mathematics curriculum in New Zealand has been the Cockcroft report “Mathematics Counts” (Committee of Inquiry into the Teaching of

Mathematics in Schools, 1982). In this document, the influence of affect was highlighted. The secretary of the Cockcroft committee wrote:

Although there are many people who are able to cope confidently and competently with any situation which they may meet in the course of their everyday life which requires them to make use of mathematics, the results of the study make it clear that there are many others of whom the reverse is true. Indeed, the extent to which the need to undertake even an apparently simple and straightforward piece of mathematics could induce feelings of anxiety, helplessness, fear and even guilt in some of those interviewed was perhaps the most striking feature of the study (Mann, 1984, p. 1).

Affect is understood to be an integral part of problem solving and learning processes (Op 't Eynde, De Corte, & Verschaffel, 2002, 2006). A direct link is often assumed between affect and mathematical achievement (Leder & Forgasz, 2006), yet research which links the two generally does not indicate the direction of influence between them (Zan, Brown, Evans, & Hannula, 2006). Some researchers do not seek to understand the relationship between affect and learning, possibly believing a student's (positive) affect is significant *per se* (e.g., Falsetti & Rogríguez, 2005). Grootenboer (2003a) discussed, although there is little hard evidence about positive affect being beneficial in terms of learning outcomes, it is certainly desirable. Just as mathematics as a subject of study "should not be judged worthwhile only in so far as it has clear practical usefulness" (Mann, 1984, p. 2), research into affect in mathematics education should not be judged worthwhile only in so far as it has clear links to achievement. Improving students' positive affect and appreciation of mathematics should be considered a goal, even a moral obligation, in mathematics education and in research.

Affective goals are explicit in Mathematics in the New Zealand Curriculum and within this curriculum there are many references to affect and related fields, for example:

Students need to:

- Communicate competently and confidently by listening, speaking, reading, and writing, and by using other forms of communication where appropriate;
- Convey and receive information, instruction, ideas, and feelings appropriately and effectively in a range of different cultural language, and social contexts;
- Estimate proficiently and with confidence;
- Use calculators and a range of measuring instruments confidently and competently;

- Show initiative, commitment, perseverance, courage, and enterprise;
- Develop constructive approaches to challenge and change, stress and conflict, competition, and success and failure;
- Develop self-esteem and personal integrity (Ministry of Education, 1993, p. 18).

Despite the evident importance of affective research, studies in mathematics education relating to the affective domain remain relatively small in proportion to purely cognitive studies. This may be because of methodological difficulties associated with ethics and measurement issues relating to the need for reliable empirical studies and measurement. These issues are discussed in more detail in Chapter Four. It may also be to do with the view of mathematics as a “purely intellectual endeavour, where emotion has no place” (Hannula, Evans, Philippou, & Zan, 2004, p. 109).

In recent years, researchers in education have paid more attention to social and cultural factors and there has been an increasing interest in the notion of *identity* (Sfard & Prusak, 2005b), which can be seen, at this stage of the thesis, as ‘who one is’ (Op 't Eynde et al., 2002). Identity researchers relate theories from social psychology, anthropology, and sociology (Holland, Lachicotte Jr., Skinner, & Cain, 1998). Studying a student’s affect through their mathematical journey is a useful aim, but this needs to be done in the context of the student’s journey as a whole, and it is in this regard that the notion of students’ identities is potentially useful. The concept of identities is explored in Chapter Three.

This research is about adolescent students. Early adolescence has been identified as a particularly precarious stage regarding changes in achievement, beliefs and behaviours.

More so than at other ages, young adolescents doubt their abilities to succeed at their schoolwork, question the value of doing their schoolwork, and decrease their effort toward academics (Ryan & Patrick, 2001, p. 439).

Adolescence is a period in which individuals experience many changes. There are biological changes associated with puberty, cognitive changes, and numerous changes in social relations (Wigfield, Byrnes, & Eccles, 2006). Furthermore, when students begin secondary school at around 13 years of age in New Zealand, this is seen as a major life transition (Ryan & Patrick, 2001). There is the onset of external examinations, and they begin to make choices about which courses to take and whether to continue taking classes in mathematics and other school

subjects. Some adolescents deal with these changes well. However, Sullivan, McDonough and Harrison (2004) note a decline in the school engagement of adolescents as compared with their engagement in primary school characterised by student malaise, increased truancy, a greater incidence of disruptive behaviour, alienation and isolation, missed life opportunities, high drop-out rates, and reduced employment prospects. Wigfield et al. (2006) describe adolescence as a time where students have particular tensions between the different communities they are involved in. Sports and social activities with peers often take precedence over school activities during this time. Friendships and social acceptance are particularly vital.

Adolescent students are therefore at a critical point in the development of their views of mathematics and affective responses and this is the age when mathematics becomes non-compulsory at the school and when students begin to make decisions about their mathematical futures. Indeed, Picker and Berry (2001) note early adolescence to be the age described by many mathematicians as being the time when they first knew that mathematics was going to be their life-long study.

In a review of Australasian literature on affect in mathematics education conducted in 2008, only 17% of the participants across the research were aged between 13 and 18, and there was need expressed to study this group more (Grootenboer, Lomas, & Ingram, 2008). Identity research has been mostly on pre-service teachers (Kaasila, Hannula, Laine, & Pehkonen, 2005; Klein, 2004; Walshaw, 2004b), teacher educators (e.g., Smith, 2006) and in-service teachers (e.g., Hodgen & Askew, 2007). Students have been somewhat less researched. The selection of participants in the current research answers the call for a greater understanding of school students' affectivity (Grootenboer et al., 2008; Leder & Grootenboer, 2005a; Schuck & Grootenboer, 2004) and combines this understanding with research in the field of identity.

## **1.5 My own mathematical journey**

Throughout my own mathematical journey, I have had a dynamic relationship with mathematics, and have experienced a range of affective responses to the subject. Not only does describing my journey communicate a further rationale for my thesis, the elements of my journey are connected to decisions I have made about how my research was conducted and communicated.

I experienced mathematical success in primary school. I particularly remember one teacher, who emphasised speed, accuracy, and competitiveness in times-table races by awarding small, lathed wooden candlesticks as prizes, several of which I won. I continued to experience success in my small rural secondary school. In my final year, with only seventeen other students enrolled in Year 13, I was often the only one who passed the Calculus examinations and was the top achiever in Statistics. I was the ‘go-to-girl’ for mathematics problems, a role I relished. It felt good to help people, and it felt good to do well when others around me struggled. Maths was my thing.

I did suffer minor anxiety about mathematics at home. My father enjoys physics and mathematics and relishes discussions relating to these fields. As the supposedly other mathematically minded person in the family, I wanted to engage in the discussions, but I had a panic reaction to them, a sort of white noise, which I needed to filter out to attempt a discussion. It was my perception at the time that he was disappointed in my lack of understanding and I felt guilt about not enjoying these discussions and not engaging in them fully.

At seventeen, in my first year of university, I enrolled for a major in mathematics. My first year away from home was lively and I missed lectures. My examinations exposed gaps in my knowledge and the following year, because mathematics was taught cumulatively I often did not understand new concepts and therefore did not continue to have the good feelings I associated with mathematics success. I became more anxious about doing the mathematics and did not ask for help. Mathematics was no longer my thing. It was not until the fourth year of my degree that I started achieving well again, though some of the anxiety remained.

After university, I worked in an aluminium smelter as a statistician. Perhaps because I was the only statistician in a team of confident engineers, my slight anxiety was compounded. When someone said to me “I’ve got a five minute problem for you” this produced the familiar minor panic – the white noise that I needed to suppress to work on the problem. What I did discover during those years was that I was not alone. The operators and technical staff also demonstrated negative affect about mathematics and often lacked understanding about concepts they used every day in statistical process control. I responded to this by holding workshops that taught operators and technical staff the background to the mathematics they used in their jobs. In the workshops, I continually found I needed to deal with people’s feelings about mathematics before they were able to access the content offered.

When I started teaching mathematics in a secondary school I found many students were having difficulty learning concepts and achieving to what I perceived to be their academic potential because of anxiety about the subject or a lack of involvement in it. It seemed to me that students in the top classes often had more anxiety than students in the lower classes. Parents seemed to mirror these feelings with their own, and as I became more involved in the running of the mathematics department, I realised many of the teachers also experienced mathematics anxiety, particularly those who were teaching to a higher level than they were comfortable with or qualified for.

During my teaching career in secondary mathematics classrooms, a student tried to push me down the stairs. There was a very minor scuffle, and I didn't fall. The boy and I were both a little shocked. He explained to me that he quite liked me. I wasn't the problem. The fact that I was a maths teacher however meant that I "needed to go". This boy was intensely afraid of maths, and therefore the maths classroom and maths teachers were objects of fear as well. He was so upset during a normal mathematics lesson that he visibly sweated and his breath smelt acidic. Another student was pleasant and jovial in class, had a good relationship with his classmates and me, and did his work to the standard required. Directly before the end of the year exam, however, he vomited outside the school hall and then fainted because of fear. I asked him what was the worst that could happen. He said that the worst thing would be if he failed. I asked what would that mean – would it make a difference to his life overall? He said it would not. He could not rationalise his extreme anxiety. He said he did not experience such anxiety in other subjects, and even enjoyed those examinations.

I have frequently been confronted with statements from other people "I am useless at maths", "maths is not my thing", "I hated maths at school". When my son started school, his teacher told a large room of new-entrants' parents that she was a "bozo" at maths. Describing the mathematics curriculum, she said that patterns were very important to help with later algebra, adding that she "was hopeless" at algebra herself. I have always found it surprising and frustrating that, even though people would only reluctantly admit they did not enjoy reading or were not literate, it seems quite socially acceptable to be negative about mathematics and to admit to a lack of understanding or success in the discipline. My son's teacher seemed quite cheerful about it, perhaps using her dislike of mathematics as a way of connecting with the parents!

All of these experiences in my own journey formed the rationale for doing this PhD. The PhD provided me with the structure and resources to explore these issues, and more specifically to explore them with students in Years 10 and 11, when my experience suggested that these negative feelings increased dramatically.

## 1.6 The research

This thesis has been a journey too, and part of this journey has been the development of research questions. I sought to explore the issues around students' decisions about their participation in mathematics, and the relationship between their identities, affect, and their learning in mathematics. What I am seeking to do, of course, is the same as all other mathematics education researchers: to ultimately improve the mathematical learning of students. However, my research questions specify this aim.

This research seeks to investigate the mathematical journeys of a class of adolescent students in New Zealand by exploring the following questions:

1. What is the nature of students' relationships with mathematics?
2. How are these relationships associated with mathematical learning?
3. How do these relationships change over time to form mathematical journeys?

## 1.7 Organisation of thesis

In Chapter Two the literature of the affective domain is discussed according to its chronological development, the main elements being: beliefs, attitudes and emotions, and the issues that surround this domain. Specifically, the relationship between affect and students' learning is explored. In Chapter Three the different perspectives of identity are discussed particularly in terms of the different views of student knowledge and learning. Like the relationship between affect and students' learning, the role of identities in students' learning is discussed. Chapter Four details the research methodology in terms of design, data collection and analysis, and further communicates decisions during the research process. Chapter Five explores the views the students had about mathematics and how the students associated these views with their engagement in the subject. Chapter Six describes students' feelings about mathematics and explores the interaction between their feelings and identities. This chapter also details the formation and change within the students' relationships with mathematics. Chapter Seven focuses on four students, analysing their affect and identities in their mathematical journeys. Each of the students' journeys highlighted different aspects of

students' relationships with mathematics. Chapter Eight answers the research questions by presenting and discussing the conclusions of the thesis and the implications of these conclusions. The limitations of the research, the specific contributions it has made to mathematics education research, and further research are also discussed.



# CHAPTER TWO: Affect in Mathematics Education

In this chapter, research about students' affect in mathematics has been examined. In section 1.4, the experience of feelings and emotions (affect) is introduced as an important part of students' relationships with mathematics and integral in their decisions to disengage with the subject (Ma, 2001). This chapter describes the emerging understanding in the previous research of the role that affect plays in students' learning.

Barton (2003) expressed his concern that research in the area of affect is often based on unproven assumptions, and he discusses this in relation to research into teachers' attitudes.

There is not a lot of point in researching how to change teacher attitudes unless we know that teacher attitudes are a significant factor in student learning. I believe this connection will be extremely difficult to research properly, although studies of attitudes are relatively easy to undertake. We should be careful about doing research that is easy, rather than research that contributes to our understanding of mathematics learning (Barton, 2003, p. 85).

How a researcher understands and uses the term *learning* depends on their theoretical approach. In the wider field of mathematics education, two major theories of intellectual development have been dominant: *constructivism*, which is seen as part of the cognitive perspective (Greeno, Collins, & Resnick, 1996) and, more recently, *socioculturalism*, which includes the situated perspective (Lerman, 1996). Discussed in more detail later in this chapter, the main differences in these perspectives arise in the ways that the interaction between the individual and the social are theorised and the extent to which researchers take account of the context within which the learning process takes place. In the affective literature, theoretical perspectives on learning are often unexplored or a cognitive perspective implied.

Despite this, there have been developments in the understanding of the relationship between affect and learning in the affective literature. In this chapter, affective research has been categorised into three genealogical phases, which emerged as the literature was reviewed.

These phases describe the emerging understanding of the role that affect plays in students' learning. In Phase One, the relationship between affect and learning was largely assumed and researchers rarely described their theoretical perspectives. In Phase Two, researchers often had a cognitive perspective and viewed mathematics learning to be an individual endeavour. In Phase Three, there is a range of theoretical perspectives and some movement towards understanding learning as a social phenomenon. The main points of each phase are summarised in Table 2.1 below. In this chapter, the associated affective research for each phase is described, the relationship between affect and learning is explored, and some of the issues with each phase are discussed. These phases contributed to understanding of the affective domain, and importantly, contributed to decisions on how the research in this thesis was undertaken. Described fully in Chapter Four, this research was qualitative and conducted with an understanding that a student's learning is fundamentally social. Learning takes place in a complex situation, which is uniquely interpreted by each student.

**TABLE 2.1 Summary of Chapter Two**

<b>Phase One</b>	<b>Key terms</b>	<b>Common type of research within this phase</b>	<b>Main outcomes and connection of affect and learning</b>	<b>Unresolved issues</b>
	Anxiety  Attitude  Achievement	<ul style="list-style-type: none"> <li>Large-scale quantitatively analysed questionnaires and use of achievement data.</li> </ul>	<ul style="list-style-type: none"> <li>Students have a range of, often negative, affective responses to mathematics.</li> <li>Students' affect is cumulative and learned from previous experiences.</li> <li>Students' positive affect is generally associated with higher achievement.</li> <li>Students' negative affect is related to lower achievement and a lack of participation in mathematics courses.</li> <li>Students' difficulties with mathematics and their performance may be more to do with their belief in their ability and their engagement in the subject rather than their innate ability.</li> <li>Students with mathematics anxiety are more likely to avoid mathematics.</li> <li>Students with a high level of mathematics anxiety experience a reduction in their working memory that affects their mathematical performance.</li> </ul>	<ul style="list-style-type: none"> <li>In Phase One, researchers often deemed a student's positive affect to be the research outcome without connecting it to student learning.</li> <li>Inconsistent definitions of attitude and anxiety make it difficult to interpret and compare research.</li> <li>The theoretical underpinnings of research are largely un-stated.</li> <li>Large-scale quantitative questionnaires and achievement data fail to take into account the situated nature of learning and doing mathematics.</li> <li>The direction of influence between affect and achievement is unclear.</li> </ul>

<b>Phase Two</b>	<b>Key terms</b>	<b>Common type of research within this phase</b>	<b>Main outcomes and connection of affect and learning</b>	<b>Unresolved issues</b>
	<p>Affective domain</p> <p>Beliefs</p> <p>Attitude</p> <p>Emotions</p>	<ul style="list-style-type: none"> <li>A mixture of large, quantitatively analysed, questionnaires and more qualitative research with structured and semi-structured interviews centered around small problem-solving tasks.</li> </ul>	<ul style="list-style-type: none"> <li>Research in Phase Two considers both affective and cognitive factors when exploring students' mathematical learning.</li> <li>Beliefs, attitudes, and emotions are described as the main elements of an affective domain. These vary in terms of stability, intensity and levels of cognitive involvement.</li> <li>It is the relationship between the elements of the affective domain that are thought to be important in understanding students' mathematical learning.</li> <li>Beliefs are thought to be the context within which emotional responses to mathematics develop.</li> <li>The ways students' view mathematics has implications for the ways they engage in the subject.</li> <li>How a student feels about themselves in relation to mathematics is associated with achievement, the activities they choose to participate in, how much effort they expend, how long they persist in these activities, and whether or not they continue in mathematics.</li> <li>There is some acknowledgement in this phase that it is important to understand the social and physical context in which affective responses take place and the students' beliefs about the context.</li> <li>Students' attitudes deteriorate as they move through secondary school.</li> </ul>	<ul style="list-style-type: none"> <li>There continues to be debate about the inclusion and the definitions of the elements in the affective domain and the definitions and categorisation of the elements.</li> <li>Less intense emotional states such as boredom have not been adequately accounted for.</li> <li>Beliefs, attitudes and emotions have all been related to achievement and other indicators of learning, but the direction of influence often remains unclear.</li> <li>The situated nature of affective responses and learning mathematics is not researched adequately in terms of empirical research within the classroom.</li> <li>There are difficulties in researching affective variables because it is not clear how to collect data relating to them because of their dependence on the current context.</li> </ul>

Phase Three	Key terms	Common type of research within this phase	Main outcomes and connection of affect and learning	Unresolved issues
	Mathematical core  Affective pathways  Appraisals  Self-regulation	<ul style="list-style-type: none"> <li>A range of methodologies and methods used.</li> </ul>	<ul style="list-style-type: none"> <li>In Phase Three, researchers use a variety of theoretical frameworks that all view affect as an essential feature of learning rather than a side effect of cognition.</li> <li>The theoretical frameworks vary according to how social factors are incorporated into the learning process. All researchers associated with this phase agree that social factors influence the learning process to some extent. For some, learning is a <i>social phenomenon</i> – a social practice situated in the mathematics classroom.</li> <li>Students have a mathematical core that includes knowledge, strategies, beliefs, needs, global affects, habitual affective pathways and behaviours, meta-knowledge, affective competencies and self-regulatory skills. These cores are dynamic, and change as new learning situations are experienced.</li> <li>Affect meaningfully encodes information that activates appraisal and self-regulatory processes. Students appraise their progress against their mathematical core and the current context of the learning situation. This process results in unique mathematical learning experiences and performance outcomes.</li> <li>The classroom culture contributes to students' engagement in mathematics.</li> </ul>	<ul style="list-style-type: none"> <li>Research that views students' learning as a product of individual cognitive processes or researches students outside of a classroom context has limitations. Affective responses and learning are situated in the practices of the mathematics classroom. Classroom-based research is therefore needed to incorporate the social nature of learning and participation.</li> <li>The social practices of the context that knowledge is formed in needs to be focussed on.</li> <li>There are few examples where students' perspectives of how their feelings and learning are associated. There is even less research on how this changes over their mathematical journey.</li> </ul>

## 2.1 Phase One: Measuring anxiety and attitude

In Phase One, most research involved large-scale questionnaires that measured mathematics anxiety and attitude. Research in this phase was generally completed before 1990, but research using large-scale questionnaires or data relating to mathematics anxiety or attitude continues to be published (e.g., Barkatsas, 2005). This research is important in the understanding of affective issues because it demonstrates the need for careful definitions and provides evidence of some association between affect and achievement. There is also some suggestion that affect may account for students' difficulties and performance in mathematics opposed to their ability or intelligence.

In Phase One (as described in section 1.4), a simplistic definition of mathematics anxiety was generally understood to be a relatively intense, negative reaction to mathematics (Hendel & Davis, 1978). In this thesis, *anxiety* is seen more specifically, using the oft-quoted (e.g., Ashcraft & Moore, 2009; Chiu & Henry, 1990) definition of Richard and Suinn (1972) where mathematics anxiety is conceptualised as “a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (p. 551). On the other hand, *attitude* was assumed to be a general liking or disliking of mathematics and a predisposition to respond in a favourable or unfavourable way (Hart, 1989). When attitude is discussed in this thesis, this is the definition that is intended. These concepts are not defined consistently in research making it difficult to interpret and compare research. Indeed, many researchers who have investigated these concepts make no attempt to define them (e.g., Beasley, Long, & Natali, 2001; Salinas, 2004; Tobias, 1990). Others view ‘anxiety’ and ‘attitude’ to be overlapping terms. For example, Schoenfeld (1985), described mathematics anxiety as a subset of mathematics attitude. Ma and Xu (2004) described a dislike of mathematics as a psychological reaction to mathematics anxiety. Ashcraft and Moore (2009) also seemed to join the concepts of anxiety and attitude when they talked about mathematics anxiety as a “person’s negative affective reaction to situations involving numbers, maths, and mathematics calculations” (p. 198). Bessant (1995) described mathematics anxiety as “a euphemism for debilitating test stress, low self-confidence, fear of failure, and negative attitudes toward mathematics learning” (p. 327).

There are also contradictions in how these affective constructs are thought to operate. Ma and Xu (2004), for example, described mathematics anxiety as a condition created and re-created

at the moment of engagement seemingly without any cumulative effect on the person experiencing it.

Mathematics anxiety is generally defined as a discomfort state created when students are required to perform mathematical tasks (Ma and Xu, 2004, p.165).

Other researchers into mathematics anxiety do not support this implication. Scarpello (2011) described the phenomenon as a learned condition. Fennema (1979), discussing the quantitative results of her oft-cited research of 1600 secondary school students (Fennema & Sherman, 1976), described negative affect as developing over a period of years. Arem (1993) writing not from empirical research but from her experience as a college-level mathematics anxiety counsellor described her view of how students' previous negative experiences lead to negative self-talk and anxiety resulting in poor mathematics progress, failure, and avoidance.

Unpleasant encounters with math in formative years can be ruinous to subsequent learning. Students who were made to feel bad about math become wary and prejudiced against it, mistrusting their own ability. New experiences in math, seen in light of the old, are tarnished by the troubled past, which only accentuates and reinforces long-entrenched negativity (Arem, 1993, p. 19).

Mathematics anxiety or a negative attitude to mathematics was often described in the literature as a condition or trait someone has. The early research of Dutton and Blum (1968), for example, defined a person's attitude as a "learned, emotionally toned pre-disposition to react in a consistent way, favourable or unfavourable, toward a person, object, or idea (p. 259). This definition is generally still being used in research, or implied in its use (e.g., Hemmings, 2010). There is no dynamic element included in this definition. Greenwood (1984) talked about students who contract mathematics anxiety and describes it as an insidious condition and discusses a cure, and treatments for mathematics anxiety continued to be discussed (e.g., Sherman & Wither, 2003). There is objectification in giving a person this label that would surely compound any anxiety a student experiences. A person does not *have* mathematics anxiety. Rather, it is something they may experience when they encounter a mathematical situation. Mathematics anxiety needs to be examined in relation to the context the person is situated in, and research into mathematics anxiety needs to account for this.

Other researchers separated affect from any inherent traits or mathematical ability. Krantz (1999) described mathematics anxiety as an "inability by an otherwise intelligent person to

cope with quantification, and more generally, mathematics (p. 100). Tobias (1990) viewed mathematics anxiety to be more about students' belief in themselves.

[Mathematics anxiety is] not a failure of intellect, but of nerve ... the most average student has the cognitive equipment they need to do advanced algebra ... the problem is they don't believe they do (Tobias, 1990, p. 91).

These views seem to imply that experiencing difficulty in mathematics and poor performances may be due to students' belief in their ability rather than any innate ability or intelligence. However, there is little empirical research in Phase One that explored this. The literature in Phase One described a multitude of symptoms of mathematics anxiety or a negative attitude. Some are physiological such as the churning of the stomach (Burton, 1979), faintness (Sovchik, 1996), hair pulling, headaches, increased heart rate and breathing levels (Ma & Xu, 2004; Richardson & Suinn, 1972; Sovchik, 1996), eye-tics (Sovchik, 1996), perspiration, nausea (Krantz, 1999), and the urge to urinate (Burton, 1979). Others relate to barriers in mathematical problem solving such as mental disorganisation (Ma & Xu, 2004) and paralysis of thought (Krantz, 1999; Ma & Xu, 2004; Reyes, 1984). Students also express a number of feelings such as distress (Ma & Xu, 2004), dread or fear of mathematics (Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998; Ma & Xu, 2004; Miller & Mitchell, 1994), frustration, helplessness, lack of confidence, uncertainty, low motivation (Reyes, 1984), lack of enjoyment (Sheffield & Cruikshank, 2000), uneasiness (Schoenfeld, 1985) and worry (Ma & Xu, 2004). These feelings are often accompanied by poor classroom behaviour (Reyes, 1984).

These responses to mathematics are generally assumed in the affective literature in Phase One to be debilitating and negative and there is an assumption students' negative attitudes should be turned into positive ones (Zan & Di Martino, 2007). Little research has been done into positive affective responses or into the varying intensities of these responses. Furthermore, the categorisations and associations between these responses are often assumed and there is little research into whether these affective responses are unique to the subject of mathematics.

Although there are many publications relating to mathematics anxiety and attitude written from the author's own experience (e.g., Burton, 1979), the majority of studies used large-scale, quantitatively analysed questionnaires to measure these constructs. Studies relating to mathematics anxiety and attitude in this phase were often based on three beliefs:

- It was “common sense” (Kulm, 1980, p. 366) that mathematics anxiety and attitudes toward mathematics had an impact on achievement in mathematics assessment;
- Achievement in an assessment was an indication that learning had taken place;
- A student’s low mathematics anxiety and positive attitude were, in themselves, a significant goal in research and education.

Consequently, many mathematics anxiety researchers measured the worth of different teaching approaches using measurements of mathematics anxiety or attitude as an indicator of improvement. For example, Jennison and Beswick (2010) compared the mathematics anxiety of students aged around 14 when an alternative teaching approach to fractions was introduced. Other researchers have evidenced improvements in teaching approaches with measures of student achievement (e.g., Norwood, 1994).

Early instruments to measure anxiety or attitude, such as the Thurstone-type instrument (Dutton, 1961) and the Likert-type instrument (Aiken & Dreger, 1961), often lacked validity and consistency. The statements used were both contextually and theoretically mixed and the scales often only measured a single affective dimension, such as whether students liked or disliked mathematics. The measurement of affective variables and the resulting statistical analyses became more sophisticated with large-scale multivariate investigations. Richardson and Suinn (1972) introduced the widely-used Mathematics Anxiety Rating Scale (MARS), a self-reporting instrument, which arose from a perceived need in the psychological literature to develop a measure of mathematics anxiety separate from other types of anxiety. Rather long and unwieldy, there are several shortened versions of this scale still in use (Ashcraft & Moore, 2009). Fennema and Sherman (1976) developed a set of nine multivariate Likert-type scales mainly for gender-related research in secondary students. This instrument had separate scales for attitude and anxiety and seven other scales including ‘confidence in learning’. A more recent addition in this phase is an instrument designed by Chiu and Henry (1990), which was designed to identify children with high mathematics anxiety.

The statistical analysis and use of large-scale questionnaires have a number of problems. McLeod (1994), in describing an attitudinal study by Higgins (1970), thought it

... demonstrated many characteristics of the era’s approach to research on affect. ... The standard statistical techniques were used with considerable care, and the use of some statistical quantitative techniques were thought to be an asset, at least in the eyes of some reviewers. The theoretical underpinnings for the research were largely

unstated, and the characteristics of the statistical models received more emphasis than the characteristics of students in classrooms (Higgins, 1970, p.638).

For example, Wilson (1997) researched 178 graduate students at the University of Mississippi to examine the relationship of student anxiety to their characteristics. Quantitative methodology was employed. The students filled in a questionnaire and multiple regression analysis was performed on their responses. 37% of the variability of student anxiety was explained by a number of factors including gender, age, mathematics preparedness, ability, previous mathematics courses studied, and strategies the teacher used for alleviating anxiety. Wilson (1997) concluded that what students bring to the classroom is more powerful in predicting students' anxiety than anything teachers can do to prevent it. Even though the findings may be statistically valid, this research is only somewhat helpful explaining student anxiety because they experience it when they are situated in a social context, and this was not accounted for. A description of the students' perceptions of sociocultural factors, descriptions of their physical environments, and an account of the social norms within the classrooms would also have been helpful in explaining the students' anxiety.

The research in this phase, to an extent, evidences a relationship between anxiety, attitude, and achievement. At a secondary school level, positive attitudes towards mathematics consistently related to lower mathematics anxiety. Also at this level, mathematics anxiety was consistently negatively related to mathematics performance with low correlation (Hembree, 1990; Ma & Xu, 2004). In attitude-related research, a weakly positive correlation is consistent between students' attitude and achievement (Kulm, 1980). In other words, a more positive a student's attitude towards mathematics is, the higher their performance. Similarly, the more mathematics anxiety a person experiences, the poorer their mathematics performances. However, the direction of influence between affect and achievement is often unclear or unexplored (Zan et al., 2006). It is unclear, therefore, whether positive affective experiences lead to students' achieving at a higher level or whether students experience positive affect *because* they are achieving well. A reciprocal relationship is often assumed.

It is likely that a student who feels very positive about mathematics will achieve at a higher level than a student who has a negative attitude towards mathematics. It is also likely that a high achiever will enjoy mathematics more than a student who does poorly in mathematics (Reyes, 1984, p. 558).

and participation.

Ashcraft and Moore (2009) suggest that there are negative personal and educational consequences of mathematics anxiety which affect a substantial percentage of the population. One of the main consequences of mathematics anxiety is avoidance. This includes avoidance in terms of participating in elective mathematics courses (Ashcraft, 2002; Hembree, 1990; Schoenfeld, 1985). Highly-anxious students seem to take fewer secondary school mathematics courses and show less intention to enrol in further mathematics when they leave school (Hembree, 1990). Also, students with higher mathematics anxiety participate less within the classroom, engage in the work to a lesser extent, study less, and do less homework. Linked to this, students with high mathematics anxiety have lower motivation and self-confidence (Ashcraft, 2002).

In early studies of mathematics anxiety, mathematics anxiety was thought somehow to interfere with the process of doing mathematics (e.g., Richardson & Suinn, 1972) but it was not discussed in any detail. Ashcraft and Moore (2009) outlined research into the “mental mechanisms” (p. 198) that operates when students are engaged in a specific mathematics problem. They suggested that there are on-line cognitive consequences of mathematics anxiety “which are relevant to the actual doing of mathematics *in the moment*” (Ashcraft & Moore, 2009, p. 200, author's own emphasis). Students with higher mathematics anxiety were found to process procedures slower, with more effort, and with more errors than their less anxious classmates (Ashcraft, 2001). While he acknowledged there is some correlation between anxiety and achievement, Ashcraft (2001) viewed students’ mathematical ability as too simple an explanation for the disparity in doing mathematics for the anxious and non-anxious groups. Rather, he attributed at least part of students’ difficulties to the capacity of their working memory – their ability to hold information in the mind important when doing abstract, complex problems with a high degree of sequencing. In a series of experiments on undergraduate psychology students, Ashcraft (2001) found that working memory was negatively associated with mathematics anxiety. When their anxiety was aroused, the students worried and experienced self-doubts and as a consequence of these interruptions had an on-line reduction in their limited working memory. This suppressed their performance in mathematical tasks that relied on working memory. In other words, mathematics anxiety disrupted the students during their learning of mathematics.

The research discussed above into on-line consequences has clear definitions and a fine-grained approach to understanding the cognitive consequences of mathematics anxiety.

However, in much of the research relating to mathematics anxiety and attitude, the large body of statistical analyses of students' affect, the poor definitions, lack of theoretical foundation, and the simplicity of the scales often result in conflicting evidence about the relationships between affective variables and achievement. If the students perform poorly in an assessment as part of the research, it is unclear whether the researchers attribute this to mathematics anxiety, a poor attitude, or the closely related concepts of test and general anxiety (Richardson & Woolfolk, 1980). A student's achievement in an assessment may indicate their level of mathematics anxiety or attitude. On the other hand, it may be because of test anxiety, the immediate context of the assessment, their previous experiences of that topic, or because of a multitude of other factors rarely explored in Phase One.

Furthermore, the situated nature of students' learning is not taken into account. There is only passing discussion of students as social beings participating (or not participating) in the tasks of the mathematics classroom.

The way a student affectively responds to mathematics is part of their relationship with mathematics. If a student has continuing negative mathematical affect, this can shape their mathematical journeys because of probable associations between affect, achievement and participation. As discussed above, students who experience mathematics anxiety or a negative attitude towards mathematics are somewhat more likely to achieve more poorly than students who experience positive affect, and their participation in mathematics is also affected.

Although researchers in Phase One have contributed to the field of affect, to enable comparisons between research outcomes, the frameworks used in their research need to be better defined. In other words, affective researchers need to better define their philosophical assumptions about what constitutes learning, and explicitly define the main concepts of their research. Furthermore, it is difficult to fully interpret the contributions of Phase One made because it is unclear how each individual study contributed to knowledge of the affective domain.

## **2.2 Phase Two: Theorising an affective domain**

Phase Two is typified by research that attempts to capture the richness and complexity of the affective domain. Research in this phase introduces beliefs as one of several elements in the affective domain, more formally defines these elements, and begins to explore the

connections between students' affect and individual learning processes. Although there have been different conceptions of an affective domain (see Leder & Forgasz, 2006), research in this phase focuses on McLeod's (1992) conception. McLeod (1992) defined the affective domain as a "wide range of beliefs, feelings, and moods that are generally regarded as going beyond the domain of cognition" (McLeod, 1992, p. 576).

By the late 1980s, despite a large body of affective research into mathematics anxiety and attitude, mathematics education research as a whole was dominated by cognitive researchers. Cognitive researchers generally view learning from a constructivist perspective and therefore are concerned with students' individual thought and information processing (cognition). Affective aspects were rarely included in these studies (McLeod, 1989).

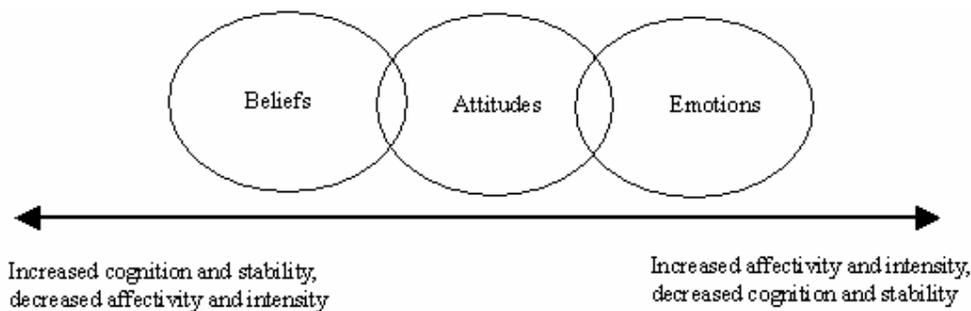
Conventional wisdom in cognitive science describe[s] people as passionless creatures who think and act rationally and coolly (Mandler, 1989, p. 4).

From this time, researchers began to include affective factors in their research. This change was reinforced by the publication of *Affect and Mathematical Problem Solving* (McLeod & Adams, 1989). This book is described as a "turning point" in mathematics education research (Zan et al., 2006, p. 115) because affect became understood to be an integral part of mathematical learning (Op 't Eynde et al., 2002, 2006). The book emphasised the importance of clarifying concepts and understanding their inter-relationship, and recommended moving beyond quantitative research methodology (McLeod & Adams, 1989).

McLeod (1992) included in his conception of the affective domain three key affective components: beliefs, attitudes and emotions. These were conceptualised as three categorisations of a range of affective responses to mathematics. These affective responses lie on a continuum of stability and intensity of responses, and levels of cognitive and affective involvement. These terms vary in the stability of the affective responses that they represent; a person's beliefs, for example, are seen as generally stable personal constructs, whereas a person's emotions may change rapidly. They vary in the level of intensity from *cold* beliefs about mathematics, to *cool* attitudes related to liking or disliking mathematics, to *hot* emotional reactions to the frustrations of solving non-routine problems. They also vary in their levels of cognitive involvement.

Beliefs, attitudes, and emotions ... differ in the degree to which cognition plays a role in the response, and in the time that they take to develop ... Beliefs are largely cognitive in nature and develop over a relatively long period of time. Emotions, on the other hand, may involve little cognitive appraisal and may appear and disappear rather quickly (McLeod, 1992, p. 578-579).

Goldin (2002) extended McLeod's model to incorporate the element of *values*, which he defined as stable, deeply-held preferences. Leder and Grootenboer (2005a) in their conceptualisation of the affective domain also included values, though Goldin, with DeBellis (2006) argued that, with values the four types could no longer be ordered on a single stability/intensity dimension, instead forming a tetrahedral model. Leder and Grootenboer (2005a) summarised the different conceptions and relationships, which is adapted in Figure 2.1. Leder and Grootenboer (2005a) included feelings in their original diagram by grouping emotions and feelings together, which is not represented here.



**FIGURE 2.1 The affective domain (adapted from Leder & Grootenboer, 2005a)**

In McLeod's (1992) view therefore, a student approaching a mathematical task has different levels of affective response to that task. They may feel anxiety about their ability to do the task (emotion). At the same time, they may have a general dislike of the topic or the subject of mathematics (attitude), and they may have a belief about how important mathematics is to their future lives (belief). Anxiety may pass quickly if the student suddenly realises how to do the problem, yet it may be a long time, if ever, before the student's belief about the importance of mathematics changes.

The affective domain is complex and consequently the division of the elements within research is thought to be problematic (Grootenboer, 2003b). Indeed, McLeod (1992) called for the study of the elements of the affective domain to be explored in a more holistic manner. He argued that it is the relationships between the elements that are seen as significant in understanding a student's affect. Emotional responses, for example, may result from a

perceived conflict with what is currently happening and beliefs (McLeod, 1994). When a person repeatedly experiences an emotion, this may lead to more stable attitudes and beliefs being formed (Zan et al., 2006).

Research in this phase generally followed Mandler's (1989) theory of emotions, which endeavoured to interpret the behaviour of students involved in mathematical problem solving. Mandler (1989) viewed emotion as a 'hot' and negative reaction to mathematics. He considered the emotional experience to be the result of *both* cognitive analyses and a physiological response. His view of the process was.

- Emotions are connected to personal goals and occur when there is a discrepancy between the individual's expectations and the demands of an ongoing activity.
- Both the physiological arousal and the person's evaluation of the situation, lead to the 'construction' of emotion.
- Emotions are variously labelled but generally include happiness, sadness, fear, anger, disgust and interest.
- Experiencing emotion may lead to a reduction in the conscious capacity available because the process of emotional construction itself requires conscious capacity. Emotions therefore bias attention and memory.
- Emotions may activate actions as students reflect on and try to control them (Mandler, 1989).

This process reflects ideas in Phase One that emotion interrupts thought and information processing. It also introduces the ideas that a person experiences an emotion because they have not met or are not meeting their expectations, and a person has various self-control mechanisms to control their emotions. However, this conception of the emotional process has been critiqued as overly simplistic because it does not properly incorporate the influence of less intensive emotional states (Hannula, 2002; Walen & Williams, 2002). Indeed, because of McLeod's (1989) conceptualisation of learning around relatively slow problem solving tasks, Ashcraft (2001) said there is no "fine-grained" (p. 224) examination of mental representations and processes.

The concept of attitude is developed in Phase Two. A person's attitude towards mathematics is described as developing through the "automatising of a repeated emotional reaction" and through "the assignment of an already existing attitude to a new but related task" (McLeod, 1992, p. 581). For example, if a student experiences frustration with an algebraic problem on

several occasions, they may form an attitude about algebra or the specific type of task they are engaged in.

Beliefs are usually considered cognitive in nature and were not included in research investigating affective factors in Phase One. McLeod (1992), however, described them as the context within which attitudes and emotional responses to mathematics develop and for this reason they were included in this conception of the affective domain. There are various debates about the concept of beliefs, including its definition, and how beliefs are separated from knowledge. Nevertheless, there is some consistency among researchers who agree that beliefs are implicitly or explicitly held (Op 't Eynde et al., 2002) and are relatively stable. Similar to McLeod's (1992) conception, Furinghetti and Pehkonen (2002) described beliefs as being less dynamic than emotions, but, because individuals continuously compare their beliefs with new experiences, they still have the potential to change.

Beliefs are often considered by researchers in mathematics education to be anything that an individual regards as true (e.g., Beswick, 2007). Such a conception of beliefs incorporates facts, opinions, hypotheses, and faith (Lester, 2002). Other researchers conceptualised beliefs to be a combination of objective and subjective knowledge. Furinghetti and Pehkonen (2002), for example, suggested that an individual's *subjective knowledge*, which is constructed by the individual and therefore internal, can be distinguished from *objective knowledge*, which is shared, external and accepted by the mathematics community. Op 't Eynde et al. (2002) similarly viewed *beliefs* to be a person's subjective conceptions and *knowledge* to be shared, correct beliefs. Mathematical content learnt in school mathematics, in this view, is seen as knowledge.

Constructivists' theories, which were developing at around the same time as the affective research in this phase, posit that knowledge is not passively received but can only be the result of the individual's own active constructions. In the constructivist view, ideas are made meaningful when they are integrated into existing structures of knowledge (Confrey & Kazak, 2006). Radford (2008) questioned this. "If we were really meant to construct everything we know, we would still be trying to light some fire in front of a dark cavern" (p. 223). Radford (2008) accepted that students' constructions through engagement in activities is one way of gaining knowledge, but said that students also need teachers to institutionalize this knowledge. Every piece of knowledge is not simply a personal construction. He cited the work of Brousseau (2004).

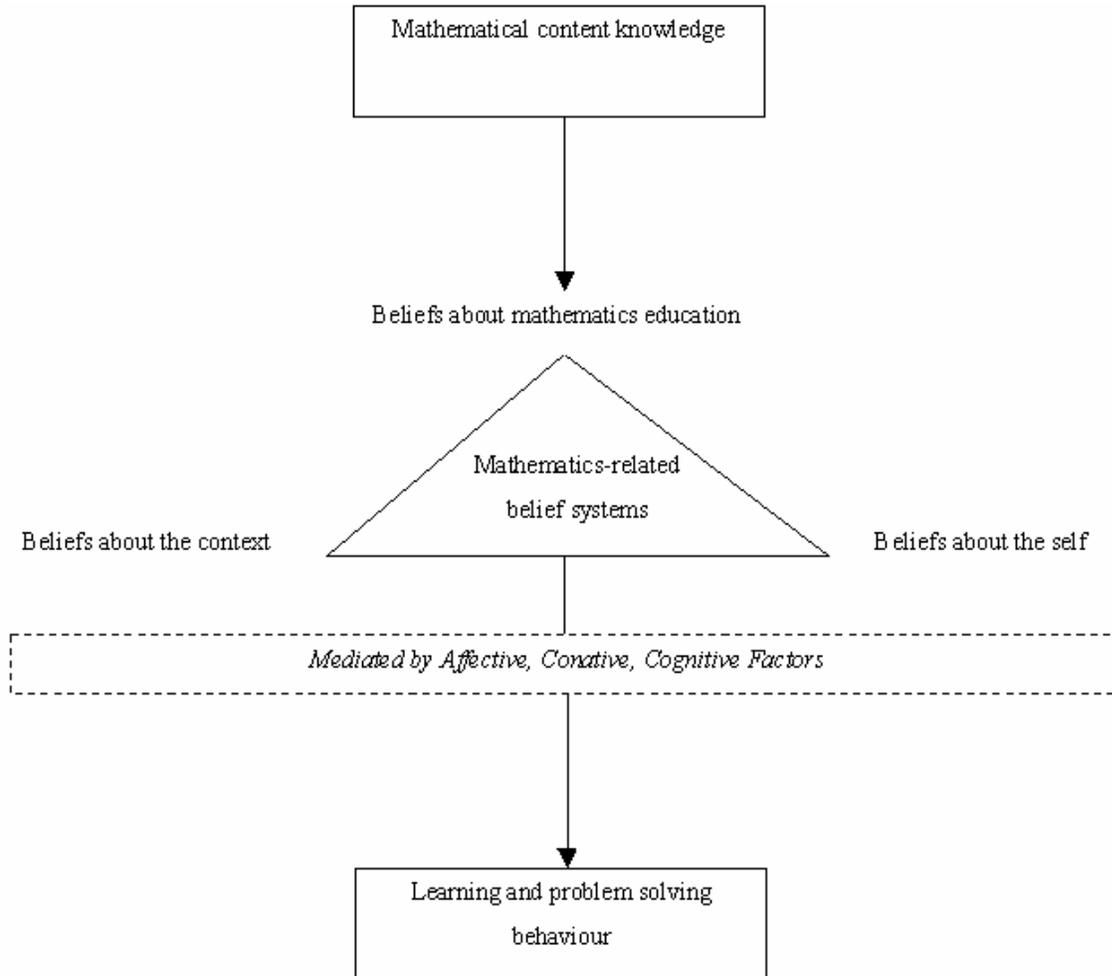
As Brousseau was able to observe over and over again in the classrooms of the Michelet School in Bordeaux, the students' subjective conceptual constructs require that an external perspective, among other things, *institutionalize* the knowledge arising from classroom mathematical activity. ... as Brousseau puts the matter, the students may not know that they know. The teacher hence has to encourage and highlight the kind of reasoning and the methods valued by the mathematicians' community (Radford, 2008, pp. 216-217).

This critique of constructivism and, more specifically, the discussion of the need for students' knowledge to be institutionalised by the teacher reinforce my concerns with affective research into beliefs in this phase. Definitions of a belief often include the assumption that what a teacher regards as mathematical content knowledge is the *correct* interpretation of the curriculum and the way it is practised by the community of mathematicians, and it further assumes the community of mathematicians have *correct* mathematical beliefs, i.e. knowledge.

Despite the concern discussed above, in this thesis, mathematical content knowledge is viewed to be the facts, symbols, concepts, and rules that constitute the contents of mathematics as a subject field as perceived by the community of mathematicians. Furthermore, students also have subjective conceptions they hold to be true, i.e. their beliefs, categorised by Op 't Eynde et al. (2002), as beliefs about mathematics education, about themselves as mathematicians, and about the mathematics class context. These definitions of knowledge and beliefs are given with an understanding that there are other definitions used in affective and mathematics education research. Leder and Forgasz (2006), observing the difficulties in defining and conceptualising beliefs, stated that fruitful discussion still could be had without full agreement on the precise definition.

Beliefs are often assumed to influence mathematical learning in a number of ways (McLeod, 1992, p. 579). Kloosterman, Raymond and Emenaker (1996) for example, viewed beliefs as significantly affecting what students do in the classroom, defining beliefs as the "personal assumptions from which individuals make decisions about the actions they will undertake" (p. 39). Again, there are different conceptions about belief definitions, which make it difficult to compare research. It is also again unclear about what influence beliefs have on mathematical learning or if learning has an influence on beliefs. According to Op 't Eynde et al. (2002), through their analysis of the beliefs' literature, it is the interaction between what they call a student's mathematics-related beliefs system and their mathematical content knowledge that –

mediated through affective, conative (motivational) and cognitive factors – determines their interaction with the social context, their respective appraisal of the situation and therefore students’ learning and problem solving behaviour. In other words, the way a student approaches a mathematical task is influenced by their content knowledge, their beliefs, and other affective, motivational, and cognitive factors. Figure 2.2 below summarises the position of Op ‘t Eynde et al. (2002).



**FIGURE 2.2 Mathematics-related belief systems**

In mathematics education there has been much research done into students’ beliefs about mathematics, mathematics education, and themselves in relation to mathematics. Two influential pieces of research were those by Ernest (1991), who categorised the beliefs students had about mathematics, and Schoenfeld (1992) who categorised students’ beliefs about mathematics learning and linked these to their behaviours and affective responses. Less research has been done into students’ beliefs about the context that they learn mathematics in.

Ernest (1991) identified three categories of conceptions that students have about mathematics:

1. The *problem solving* view where mathematics is seen as a continually expanding field of human inquiry, and therefore dynamic and problem-driven;
2. The *traditional* or Platonistic view where mathematics is seen as a static, but connected body of knowledge which is discovered rather than created;
3. The *instrumentalist* view where mathematics is seen as being a useful, unrelated collection of rules, facts, skills and procedures, which need to be memorised.

At a similar time, Schoenfeld (1992), using his year-long observations of secondary school geometry classes, summarised students' beliefs about mathematical learning.

- Mathematics problems have one and only one right answer.
- There is only one correct way to solve any mathematics problem, usually the rule the teacher has most recently demonstrated to the class.
- Ordinary students cannot expect to understand mathematics; they expect simply to memorize it and apply what they have learned mechanically and without understanding.
- Mathematics is a solitary activity, done by individuals in isolation.
- Students who have understood the mathematics they have studied will be able to solve any assigned problem in five minutes or less.
- The mathematics learning in school has little or nothing to do with the real world.
- Formal proof is irrelevant to processes of discovery or invention (Schoenfeld, 1992, p. 359).

These beliefs imply the students tend towards an instrumentalist view of mathematics, as defined by Ernest (1991). The students in Schoenfeld's (1992) research memorised the rules, facts, skills and procedures to solve problems quickly to get the correct answer. They may not have found mathematics to be useful in terms of the real world. Rather they found the rules, facts, skills and procedures useful in solving the problems they faced in school mathematics. They students have similarities to the ones in research done in New Zealand by Young-Loveridge, Taylor, Sharma and Hawera (2006) and similarly by Grootenboer (2003b). In this research students were described as having a utilitarian view of mathematics (Grootenboer & Hemmings, 2007) or, in terms of Ernest's (1991) categories, an instrumental view.

Importantly, Schoenfeld (1992) linked these beliefs about mathematics learning with students' affective responses to mathematics. In his view, the beliefs students have about

mathematics, largely shaped by students' experiences in the mathematics classroom, have implications for student behaviour and "extraordinarily powerful (and often negative)" consequences for affect and learning (Schoenfeld, 1992, p. 359). If a student believes they need to solve a problem in five minutes or less, for example, they "will give up on a problem after a few minutes of unsuccessful attempts, even though they might have solved it had they persevered" (p. 359). This is similar to the connections with affect and learning made by researchers in Phase One and in researchers working in the general mathematics education field. Richardson and Woolfolk (1980), discussed how certain features of mathematics, such as its precision, logic, and emphasis on problem solving, make it particularly anxiety provoking for some individuals. Earlier, in a position paper, Skemp (1976) similarly described how different mismatches between student and teacher views of mathematical understanding can cause distress. He described two types of understanding which individuals seek in classrooms – *relational understanding*, which is knowing what to do in a mathematics problem and why and *instrumental understanding* which is knowing rules and being able to use them, without understanding why. Distress occurs when there is a mismatch in the understanding sought between students and teachers, such as when a student aims for instrumental understanding and the teacher teaches for relational understanding, or vice versa. Frustration, and possible damage to the student's learning, can occur. Students' beliefs about mathematics and mathematics learning therefore are thought to influence students' immediate affective responses to the mathematics.

There is a lot of research connected to students' beliefs about themselves in relation to mathematics, such as self-concept, self-efficacy (Op 't Eynde et al., 2002), and confidence (Burton, 2004). How students feel about themselves in relation to mathematics seems to affect their experiences when doing mathematics (McLeod, 1992; Pajares, 1996). More specifically, students' feelings about themselves in relation to mathematics have been associated with achievement, decisions about which activities students choose to participate in, how much effort they expend, how long they persist in those activities, and whether or not they continue in mathematics (Kloosterman, 2002).

Introduced by Bandura (1977), students' *self-efficacy* beliefs are personal judgments about their academic capabilities. These are considered to be a predictor of students' motivation and learning (Zimmerman, 2000). Students who have high self-efficacy undertake difficult and challenging tasks more readily and then "work harder, persist longer, and have fewer adverse emotional reactions when they encounter difficulties than do those who doubt their

capabilities” (Zimmerman, 2000, p. 86). This leads to self-efficacious students having higher academic achievement than students with low self-efficacy.

However, often overlapping, research findings lack clarity in the terms used, and the findings can be contradictory across definitions and different contexts. Burton (2004) highlighted the problems or different definitions of ‘confidence’, and how it can be recognised or measured. Furthermore, she questioned why ‘confidence’ is often used to make generalised statements linking mathematical achievement to race and gender.

Instead of linking achievement in mathematics to individual ‘confidence’, it is legitimate to ask how far low achievement in mathematics is a consequence of structural and curriculum factors which successfully diminish many students’ interest and motivation and are then mis-labelled as ‘lack of confidence’ (Burton, 2004, p. 358).

Students’ drawing of mathematicians as an exercise originated in science education with the development of the Draw-A-Scientist Test (DAST) (Chambers, 1983). In mathematics education, Rock and Shaw (2000) invited children to send in drawings of a mathematician at work. 132 drawings were sent in from students’ aged 5-9. Most of the mathematicians were drawn in classrooms, there were more female than male figures and more than 80 percent of the figures drawn were smiling. This image of a smiling female mathematician however may have been more related to the age of the student. It is not clear from the survey what proportion of female mathematics teachers the primary students had encountered. Furthermore, because the survey was attached to a mathematics competition website those students who responded to the invitation were probably keen students. Picker and Berry (2000) used the DAST more rigorously to investigate pupils’ images of mathematicians. 476 students aged 12-13 years were asked to draw a mathematician at work, and explain their drawing in writing. The resulting images were analysed qualitatively and categorised for gender, ethnicity, and features of the mathematician. In this research, the vast majority of male students drew male mathematicians and a significant proportion of females also drew males. For example, in the USA, 94% of male respondents and 61% of female respondents drew male mathematicians (Picker & Berry, 2000). A female student drawing a male mathematician may have more difficulty in envisioning herself as a mathematician in her future.

Indeed, the image a student draws potentially reveals the views they have about the nature of mathematics, mathematicians and mathematics teaching (Picker & Berry, 2000), which is part of their relationships with mathematics. Furthermore, students' images have a powerful impact on present functioning and future plans (Huber & Burton, 1995), and therefore a student's ability to learn mathematics is thought to be related to the level of a student's perceived acceptance of being a mathematician within a mathematical community (Jaworski, 1994).

Many researchers researching affective issues do not consider students' beliefs about the context of the mathematics classroom because of their view of learning as an individual process (McLeod, 1992). *Social constructivist* theory developed when constructivists began to pay attention to social influences in the classroom (Confrey & Kazak, 2006). Like other constructivists, social constructivists endorse the process of learning as an individual's reorganising of *schemata* – knowledge structures formed from past experiences – but believe social interactions have a much higher influence on the nature and significance of the perturbations confronted by an individual (Lerman, 1996).

Human subjects are seen not as isolated individuals constructing their own personal knowledge but as members of society in which interactions with other humans determine the construction of knowledge (Lerman, 1996, p. 2).

Op 't Eynde et al. (2002) as social constructivists, viewed beliefs to be determined by the sociocultural environment in which one lives and a function of the classroom practices one participates in. They included beliefs about the context in their mathematics-related beliefs system. These refer to students' views and perceptions of the classroom norms, including the social and socio-mathematical norms, the role and the functioning of the teacher, and the role and the functioning of the students.

Within a specific classroom context, students will interpret the rules and practices of mathematics on the basis of their prior beliefs and knowledge and as such develop their own, to a larger extent shared, conceptions about it (Op 't Eynde et al., 2002, p. 32).

Yackel and Cobb (1996) set forth a way of interpreting classroom life that aimed to account for how students develop specific mathematical beliefs and values. Students' individual beliefs about their own role, and the role of others in the class are the psychological correlates

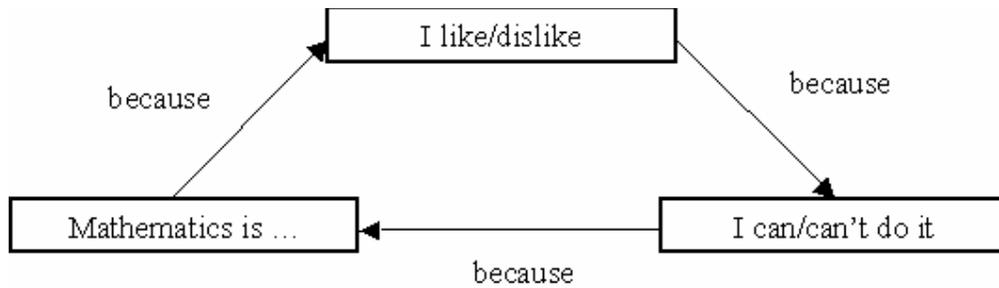
of the classroom's *social norms* relating to the role and functioning of both the teachers and students. *Socio-mathematical norms* are norms that are specific to students' mathematical activity, e.g., what constitutes a mathematical explanation.

Both classroom social norms and socio-mathematical norms, determine the interaction patterns that teacher and students mutually establish, in which implicit definitions are embedded about what mathematics is like, about how a problem should be solved, about the criteria of being a good student ... students develop their sense of what it means to do mathematics and what they and the others are expected to do in mathematics lessons from their actual experiences and interactions during the classroom activities in which they engage (Yackel & Cobb, 1996, p. 32).

These understandings which teachers and students mutually establish about what constitutes an appropriate approach to mathematics teaching and learning have been similarly conceptualised (Lange & Meaney, 2010) as a didactical contract (Brousseau, Balacheff, Cooper, Sutherland, & Warfield, 1997). This, often tacitly understood contract, develops and is maintained by the relationship between teachers and students and a wish to avoid failure of the mutual venture of students' learning. Blomhøj (1995) described (translated in Lange and Meaney (2010) that this 'interplay' can be restricted by "for example, physical conditions and time limitations, the difficulty and importance of topics, the teacher's and the students' mathematical basis, curriculum and exam provisions, their own expectations and those of the environment" (Lange & Meaney, 2010, p. 684).

Zan and Di Martino's (2007) work is an example of research which situated students within their classroom, and which answered McLeod's (1992) call to clarify definitions and to consider the affective domain as a whole. This is relatively unique because most research studies beliefs as a single construct without considering other elements of the affective domain (Grootenboer et al., 2008). As part of a larger project, over three years, Zan and Di Martino (2007) studied school students from varying age groups using a wide range of methods, including class observations, questionnaires, and interviews. One of the instruments was an autobiographical essay on mathematics. They asked 1304 students to write an essay on 'Me and mathematics: My relationship with maths up to now'. They used a grounded theory approach, described further in section 4.1.3, to discover children's definitions of attitude by understanding how the students interpreted their own experiences with mathematics. Three themes were identified in the essays. Students had an emotional disposition towards mathematics, expressed with 'I like/dislike mathematics'. They had a perception of being/not

being able to succeed in mathematics, expressed with 'I can do it/I can't do it' and they had a vision of mathematics expressed with 'mathematics is ...'. The word *because* often linked these themes as shown in Figure 2.3. These themes were seen by Zan and Di Martino (2007) as deeply connected but mutually independent. Figure 2.3 below shows the figure Zan and Di Martino (2007) used to illustrate these connections. The themes interacted with each other through *because* statements.



**FIGURE 2.3 Connections Zan and Di Martino (2007) made between attitude, self-concept, and beliefs**

Zan and Di Martino (2007) suggest that

... for a description of a pupil's attitude towards mathematics it is not enough to highlight his/her (positive/negative) emotional disposition towards the discipline: it is necessary to point out what vision of mathematics and what self-efficacy beliefs this emotional disposition is associated with (Zan & Di Martino, 2007, p. 172).

In Zan and Di Martino's (2007) research, using Skemp's conceptions of understanding, students with an instrumental vision of mathematics generally disliked mathematics, whereas those with a relational vision generally liked mathematics. This is an important research result given the earlier note that New Zealand students tend to have an instrumental view of mathematics (Grootenboer, 2003a; Young-Loveridge et al., 2006). Zan and Di Martino's findings echo McLeod's (1992) suggestion that it is the relationships between the elements that are important in the affective domain. Zan and Di Martino's research help to define better the elements of the affective domain. They do not go far enough, however, in stating what their theoretical perspective of learning is and exploring how these elements are linked to learning.

Methodology used in research in the affective domain became more qualitative in Phase Two, sometimes using a mix of quantitative questionnaires with structured and semi-structured

interviews with small problem-solving tasks. There are a number of ethical issues with directly measuring physiological responses of participants (Leder & Forgasz, 2006) and affective research has often been limited to “beliefs, attitudes and feelings that participants ... share in either a verbal or written form” (Schuck & Grootenboer, 2004, p. 12). These responses are often inferred from semi-structured interviews and Likert-type questionnaires (Grootenboer et al., 2008). In the large-scale quantitatively analysed questionnaires dominant in this literature, the concepts have often not been defined appropriately either for the participants or the reader. This has led to analysis problems in differentiating between concepts and difficulties in understanding the direction of influence. Later, multi-variate questionnaires have been more useful because of their detailed, often careful descriptions of the concepts and more rigorous analysis (Ma & Kishor, 1997). Nevertheless, the analyses from questionnaires still do not adequately describe individual differences between students’ affective responses to the learning of mathematics. In particular, they do not take into account the situated nature of learning mathematics, which is important if mathematical learning is seen as a social phenomenon, as it is in this research.

Beliefs studies continued to rely on large, quantitatively-analysed questionnaires. When small-scale studies have been done, these were usually based around problem-solving tasks done in isolation from the rest of the classroom and therefore were arguably also context-independent. In contradiction to this, other research from this phase suggests that students’ feelings are context-dependent. Feelings are connected with both the social settings and the learning experiences within them and therefore vary according to the different conditions (Burton, 2004). In research surrounding the affective domain the situated nature of learning mathematics is often not taken into account. In Phase Two, the meaning of learning as a social phenomena as well as an individual construction of knowledge has been explored theoretically (e.g., Op 't Eynde et al., 2002), but is only beginning to be explored in terms of empirical research within the classroom.

Affect is often assumed to directly influence a student’s behaviour. In the beliefs literature, for example, Furinghetti and Pehkonen (2002) described a belief to direct actions and affect subsequent learning. Raymond and Emenaker (1996) also viewed beliefs as significantly affecting students’ actions in class. Student’s emotional reactions to tasks and how they approach a problem are seen as a consequence or expression of their beliefs. Caution is needed when students’ beliefs are inferred from their achievement or the researcher or

teacher's observations of behaviour in class (Burton, 2004) as is common in educational and psychological research. Lester (2002) explained further:

A central difficulty is that the fundamental assumption undergirding much of this research rests on a shaky logical foundation. Specifically, a basic assumption is that beliefs influence peoples' ... thinking and actions AND assume that beliefs lie hidden and so can be studied only by inferring them from how people think and act. ... For researchers to claim that students behave in a particular manner because of their beliefs and then infer the students' beliefs from how they behave involves circular reasoning (Lester, 2002, p. 346).

Zan and Di Martino also shared Lester's (2002) concern that there is a risk of circularity of reasoning in affective studies. They cautioned against the frequent use in mathematics education of the dichotomy of positive/negative. What is meant as positive for beliefs, attitudes and emotions is often not taken into account. When a positive outcome refers to an emotion, 'positive' normally means 'perceived as pleasurable'.

An assumption is often made as to what should in effect be the result of an investigation, for example, that a belief which is 'positive' because it is shared by experts, is associated with a 'positive' behaviour in that it is successful (Zan & Di Martino, 2007, p. 161).

This is particularly risky when it is assumed that a positive belief is associated with a student liking mathematics. In Zan and Di Martino's research, for example, they found "mathematics is useful", generally thought of as positive, was associated with students both liking and disliking mathematics. A student could dislike the subject *because* they considered it to be important, and had difficulty in meeting the expectations associated with this.

There continues to be debate about the inclusion and the definitions of the elements in the affective domain. The three concepts in McLeod's model do not cover the whole field and it is not clear where, for example, concepts such as motivation, and identity fit. Too often there are largely descriptive studies of affect that lack any significant theorising. It is now generally established that, to understand learning in mathematics, attention needs to be paid to both cognitive and affective factors and their interaction (Leder & Forgasz, 2002). Currently, affective processes are understood to be an integral part of mathematical learning but Phase Two only begins to describe *how* this happens (McLeod, 1992; McLeod & Adams, 1989; Op

't Eynde et al., 2002, 2006). Furthermore, there is little research to describe how this learning process occurs over time. Emotions experienced in response to specific learning experiences have been related to the more stable constructs of attitude and belief, but there is not a clear understanding how this affects a student's mathematical journey over time. Clear connections have still not been made between students' mathematical beliefs, their affective processes, their learning, and their decisions to pursue mathematics.

## **2.3 Phase Three: Exploring theoretical perspectives**

In mathematics education, in Phase One the research focused on the measurement of mathematics anxiety and attitude. In Phase Two it was common to connect research to McLeod's conception of the affective domain. Researchers such as McLeod and Adams (1989), with their 'discovery' of the relationship between affect and cognition in problem solving, led the discussions. As constructivism emerged in general mathematics education research as an important learning theory, and was applied to the mathematics classroom context, this was also reflected in affective research in mathematics education. Furthermore, the theories of educational psychology continued to lend themselves well to the study of understanding why students behave as they do. Researchers in Phase Three have significantly expanded the understanding of the necessary linkages between the affective and cognitive and behaviour domains and mathematics.

Phase Three is the most difficult of the affective research stages to describe. As mathematics education researchers became more aware of the affective field's complexity, multiple perspectives and new approaches have become valued (Malmivuori, 2001; Schoenfeld, 1994). Although affective research in mathematics education has always been influenced by other disciplines, most notably educational psychology, affective research is now a multidisciplinary melting pot with wide-ranging theoretical frameworks. These differ depending on which discipline the researcher comes from, their theoretical perspectives on learning, and how they position themselves in relation to McLeod's starting framework (Hannula et al., 2004).

This variety is illustrated well by a special issue of the journal *Educational Studies in Mathematics* (Volume 63, Number 2, 2006), which extended the discussion held at PME 28, in Bergen (Hannula et al., 2004). Each of the theoretical frameworks in the different articles present persuasive explanations for students' mathematics-related experiences and the

relationship between cognition and affect. Among these, was the framework presented by DeBellis and Goldin (2006) who conducted and videotaped five clinical, task-based interviews with individual children across two years. They presented affect as an internal representational system and introduced new constructs such as *mathematical intimacy*, which “refers to deep vulnerable emotional engagement an individual may have with mathematics” (p. 132) and *mathematical integrity*, which refers to the “individual’s fundamental commitment to mathematical truth, search for mathematical understanding, or moral character guiding mathematical study” (Goldin, 2002, p. 132). These seem potentially useful in describing the quality of students’ engagement. Malmivuori (2006) used the results of a quantitative Finnish study that investigated 723 thirteen year old students’ mathematical beliefs, affective responses, self-regulatory patterns, and mathematical performances. She drew on socio-cognitive and constructivist perspectives to portray the functioning of affective responses in mathematical learning. Op ’t Eynde et al. (2006) took a socio-constructivist view of emotions. Using a combination of questionnaires, think-aloud protocols, and video-based stimulated recall interviews, they conducted a multiple case study of 16 students, aged 14 years, investigating the role of students’ beliefs and emotions during problem solving in a mathematics classroom. Hannula (2006), as a researcher/teacher, used the results of a larger longitudinal qualitative study of Finnish students, aged 13-15 year old, to view emotions as reflecting students’ goals and needs. He used the motivational system as a lens to look at mathematical behaviour. Evans, Morgan and Tsatsaroni (2006) had a discursive approach to emotions. They analysed transcripts from small groups of students doing problem solving in the mathematics classroom. Each of the theoretical perspectives in this special issue are rich in definitions and theory and contribute significantly to the domain of affect and its links to learning. In all of the perspectives, affect is viewed as an essential feature of the processes of learning (DeBellis & Goldin, 2006) rather than simply a side-effect of the various cognitive processes (Malmivuori, 2006).

This section explores how different researchers, including those in this special issue, view mathematics as an activity of participation in the social world of the classroom. Different approaches to researching motivations and emotions are then compared. Students’ conscious awareness of their affective processes is discussed. The notion of a student having a mathematical core is then explored from different research perspectives.

### **2.3.1 Mathematics as participation in a social world**

The theoretical perspectives in Phase Three reflect the growing interest and focus in mathematics education on the social and cultural context of the classroom in mathematics education (Sfard & Prusak, 2005b), and the focus on theories that see meaning, thinking, and reasoning as social products (Lerman, 1996, 2000). In much of the affective literature throughout the phases, thinking is seen as an internal mental process. Researchers aim, through the use of questionnaires and other research tools, to find out what is going in the head (Radford, 2008) and learning is seen as an individual endeavour. In Phase Three the researchers generally acknowledge that individuals learn in interaction with the social world but incorporate social factors into their frameworks of learning to different degrees. Social factors and the role of the context are often not mentioned specifically or are perceived as influencing the learning process by being facilitating or debilitating. Context is often “reduced to a kind of external environment to which the cognitive activity of the student has to adapt” (Radford, 2008, p. 216).

The theoretical perspectives in the special issue illustrate this growing interest in social factors to differing extents. Malmivuori (2006) described the mathematical learning situation as socioculturally and contextually conditioned where school mathematics learning and wider aspects of culture provide contexts which influence students’ learning and performance. Although DeBellis and Goldin’s (2006) discussion seems contained to the context of individual mathematical problem solving, they mention briefly the important influence of the “subculture” the student is situated in.

Hannula (2006) critiqued motivational work in mathematics education which used pre-defined aspects of motivation to measure aspects of motivation such as students’ motivational orientation or their beliefs (e.g. Kloosterman, 2002). He instead described the quality of students’ motivation in more detail – he found a student’s realisation of needs as goals are mediated by the school context and the social and cultural background of the student. Hannula (2002) discussed the development of the attitudes of one 13-15 year old Finnish girl Rita. Data on Rita was analysed according to a framework where ‘attitude’ was defined as a category of behaviour that is produced by different evaluative processes. “Students may express liking or disliking of mathematics because of emotions, expectations, or values” (p. 30). Rita described the classroom environment, the time of the day, and the textbook as affecting her doing of mathematics. Her affect was situated in the context of the mathematics

classroom. Hannula (2002) described Rita's evaluations of mathematics as strongly influenced by the social setting. Rita's need to belong socially and have an active role in group work affected her emotions and evaluations of mathematics.

Op 't Eynde (2004), with De Corte and Verschaffel (2001, 2006), stressed the situatedness of emotions. They distanced their stance from more cognitive perspectives by describing the context as potentially fundamentally changing the course of the learning process, rather than simply influencing it.

People are always situated in and constituted by the social and historical context(s) in which they find themselves. They give meaning to themselves and the surrounding world by interacting with it (Op 't Eynde et al., 2001, p. 151).

Op 't Eynde et al. (2001, 2006) hold, as was described in Phase Two, a socio-constructivist view of learning. It is argued that social constructivists have not gone far enough towards a social view of learning (Lerman, 1996), and a division between the individual and the world remains (Boaler, 2000). Indeed, according to Lerman (1996), social constructivists, whilst they have incorporated a function for social interactions, have not addressed a number of problems with their focus on the individual's construction of knowledge. The role of motives, goals and needs are marginalised into the separate, affective domain. Values only play a minor role, culturally-related reactions to experiences and meaning-making are difficult to account for, and there is difficulty in explaining community knowledge and the apprenticeship of people into social practice (Lerman, 1996).

However, there is, arguably, a great deal of similarities between Op 't Eynde et al.'s socio-constructivist approach and a sociocultural approach.

Student learning is ... perceived as a fundamentally social activity and embedded in the community specific classroom context and the broader socio-historical context (Op 't Eynde et al., 2006, p. 194)

In *sociocultural research*, individual's cognitions are believed to originate in social interactions.

[The] human mind is seen as constituted discursively, through practices, and in particular through language, which carries the specificities of social contexts and practices and regulates human functions (Lerman, 1996, p. 2).

Therefore, issues such as culture, motives, and social and discursive practices need to be considered as central and should be constituted as the lens through which to look at children's learning of mathematics (Lerman, 1996). This is because learning is not individual. Rather, the human brain is described as dependent on cultural resources for its operation (Radford, 2008). Context therefore needs to be seen as more than a physical space where learning is located. It is constructed in the course of social interaction (Bloomer & Hodkinson, 2000).

Learning, and indeed, learning mathematics, is therefore seen as an activity situated in a social context (Lave & Wenger, 1991) and is a social practice (Bloomer & Hodkinson, 2000). The notion of practice comes from Lave and Wenger's (1991) work on communities of practice. Based on their work studying the practices of a large organisation, Wenger (1998) described a *community of practice* as a particular physical and social context where participants have mutual engagement, a joint enterprise, and a shared repertoire. A mathematics classroom can also be described as a community of practice and students' learning of school mathematics can be considered as participation in its practices (Boaler & Greeno, 2000). Through participation, students contribute to the development of the practices established by the mathematics classroom community (Cobb & Bowers, 1999), such as the classroom's social norms and socio-mathematical norms (Yackel & Cobb, 1996). Based on their work studying the practices of a large organisation, Wenger (1998) described *practice* as the doing that gives structure and meaning to what is done.

It includes what is said and what is unsaid; what is represented and what is assumed. It includes the language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts that various practices make explicit for a variety of purposes. But it also includes all the implicit relations, tacit conventions, subtle cues, untold rules of thumb, recognisable intuitions, specific perceptions, well-tuned sensitivities, embodied understandings, underlying assumptions, and shared world views (Wenger, 1998, p. 47).

Similarly, Holland et al. (1998) discussed the development of identities within *figured worlds* where people construct joint meanings; these are recognised, culturally constructed historical processes or traditions located in time and place. Boaler and Greeno (2000) used the concept

of figured worlds in their analysis of 48 high school calculus students from six different mathematics classrooms. They conducted semi-structured interviews that were qualitatively analysed. Students' discussions about their mathematics learning were viewed as reports of their participation and understanding of the figured social world of mathematics education in which they participated as learners. Boaler and Greeno (2000) interpreted a mathematics classroom as a figured world within which people participate, and consequently construct their senses of self and take on roles that help define who they are. They described two types of figured worlds. One of the worlds was structured, individual and ritualised with didactic teaching with students positioned as passive agents. The other world was relational, communicative and connected with discussion-based teaching, where students were positioned as active agents who emphasised their role in discussion, and were mutually committed and accountable to each other for constructing understanding in their discourse. In this research, students adapted to their differing figured worlds with differing ways of knowing because it is the practices of learning mathematics that define the knowledge that is produced. There are some similarities to this conception of figured worlds and the beliefs literature in Phase Two, in particular Skemp's (1976) conception of instrumental and relational understanding. Nonetheless, there is far more emphasis on the students' participation in the social world of the mathematics classroom.

Participation in social practices is "what learning mathematics is" (Boaler & Greeno, 2000, p. 173). Even when individuals are in isolation from each other, in doing mathematics, they are participating in social practice (Cobb & Bowers, 1999, p. 5) because they encounter socially generated mathematical representations, concepts and methods. On the other hand, this idea does not exclude individual creativity in mathematics.

We are constrained but not necessarily shackled by the idea of learning as a social practice. When our social practice of learning involves questioning and querying what [has already been done], then individuals will find new ways to do things, including mathematics, and will thus be labelled as creative. ... It is the social practice of learning through querying and questioning that enables the individual to produce new knowledge (Tamsin Meaney, Personal Communication, 2009).

In this research, learning is seen as a social practice, socially and culturally constituted. Participation in the practices of the mathematics classroom is where learning occurs and therefore it is important to fully understand the context in which affective responses take

place. Students' participation in the mathematics classroom is seen as the constant process of negotiating meaning.

While engagement in practices may be familiar, it is the production of such patterns anew that gives rise to an experience of meaning ... we produce meanings that extend, redirect, dismiss, reinterpret, modify or conform – in a word negotiate anew – the histories of meanings in which they are part (Wenger, 1998, p. 52).

Very similarly, Op 't Eynde (2004) described a students' learning as taking place through engagement in the language, rules and practices that govern activities in the community of the mathematics classroom. Students are continuously seeking to integrate experiences, and through engagement, discover meaning, and renegotiate or construct new meanings.

Therefore meaning is jointly constructed

... in the sense that it is neither handed down ready-made nor constructed by individuals ... Well established meanings might be implied in practices characterising a specific community for many years, but it is through engaging in such a practice anew that the individual experiences meaning and renegotiates the currently accepted meanings (Op 't Eynde, 2004, p. 119).

Extending the knowledge discussion from Phase Two, Op 't Eynde et al. (2001) described knowledge as residing in the practices that characterise the community. Similarly, in the sociocultural perspective, students' practices are seen to co-determine their knowledge (Boaler, 2000), and therefore knowledge is socially situated. Brown, Collins and Duguid's (1989) study furthermore described knowledge as sharing significant features with tools.

[Tools] can only be fully understood through use, and using them entails both the user's view of the world and adopting the belief system of the culture in which they are used ... it is ... possible to acquire a tool but be unable to use it ... Learning how to use a tool involves far more than can be accounted for in any set of explicit rules. The occasions and conditions for use arise directly out of the context of the activities of each community that uses the tool, framed by the ways members of that community see the world. The community and its viewpoint, quite as much as the tool itself, determine how a tool is used (Brown et al., 1989, p. 33).

It is not sufficient to focus only on students' knowledge as is frequently done in mathematics education, but to include the social practices that knowledge is used in. Boaler (2002a), using

results from her in-depth comparison of traditional and more problem-focussed classrooms, said that:

... when students approached a new mathematics problem, the extent to which they are able to use mathematics depends partly on the knowledge they have developed, partly upon the practices in which they have engaged as they have learned, and partly upon the relationships they have developed with the discipline of mathematics (Boaler, 2002a, p. 113).

When learning is conceived as negotiation of meaning through participation, then learning is connected with a student's relationship with mathematics, context, affect and behaviour. Op 't Eynde et al. (2006) stated:

Students' learning is perceived as a form of engagement that enables them to actualise their identity through participation in activities situated in a specific context. Their understanding of and behaviour in the mathematics classroom is a function of the interplay between who they are (their identity), and the specific classroom context. Who they are, what they value, what matters to them in what way in this situation is revealed to them through their emotions (Op 't Eynde et al., 2006, p. 194).

### **2.3.2 Approaches to researching motivations and emotions**

Researchers take different approaches in understanding the linkages between students' affect and learning. Some measure or describe aspects of students' motivation (e.g. Martin, 2002) in order to investigate some of the reasons why students behave in the way they do. Others seek to understand students' emotions and their influence on their learning (e.g. Evans, 2000) or use of combination of motivation and emotions to understand students' learning or behaviour in the classroom (e.g. Csikszentmihalyi, 1997). The different approaches are described and discussed in this section.

Motivation is a concept from educational psychology that is conceptualised in this thesis as "the inclination to do certain things and avoid doing some others" (Hannula, 2006, p. 165). This definition is similar to that of Anderman and Wolters (2006) who see motivation as a "willingness, desire, or condition of arousal or activation" to do a task. Motivation is sometimes viewed as synonymous to behaviour. For example, with 'affect' and 'cognition', motivation (behaviour) is described as one of the ABCs of the field (Vaughan & Hogg, 2005). Ryan and Deci (2000) also talked about motivation as being "moved to do something" (p. 54).

In this thesis, motivation is seen as relating to behaviour, but only in a potential sense (as in Hannula, 2006). It is not the person's action that is the subject of study in this discussion, but their energy or drive (Martin, 2002) to perform that action.

Judging from the number of publications in this field relating to mathematics, motivational researchers have long been interested in the domain of mathematics (Murphy & Alexander, 2000). Furthermore, the construct of motivation is widely used in the mathematics education research community. The concept has already been mentioned in this thesis several times. Low motivation was described in section 2.1 as a symptom of mathematics anxiety. In section 2.2, students' motivation was noted as one of the factors which contributed to behaviour (Op't Eynde et al., 2002). Furthermore the social environment (Ryan & Patrick, 2001), and structural and curriculum factors (Burton, 2004) were described as factors which could diminish students' motivation. Motivation in mathematics education has often been discussed in relation to students' beliefs (Kloosterman, 2002), and Dweck's (1999) work on self-theories (e.g., Sullivan, Tobias, & McDonough, 2006). Williams and Ivey (2001) used the term 'motivation for engagement' to describe the degree to which students choose to actively participate in the classroom activities available to them. They linked a student's motivation for engagement with their affective assessment of mathematics. Researchers into motivation attempt to explain students' choice of tasks, their persistence and vigor when doing them, and their related performance in those tasks (Wigfield & Eccles, 2000). These aspects of students' learning are explained through research into intrinsic vs. extrinsic motivation, goal orientations, interest, and self-schema or a combination of these (Murphy & Alexander, 2000). Some of this research is explored now.

A person's motivation is often described as intrinsic or extrinsic. A person has *intrinsic motivation* when they perform an activity because of their interest and enjoyment in the activity, rather than because of a separate outcome. A person has *extrinsic motivation* when they do an activity because it leads to a separate outcome, such as a reward (Ryan & Deci, 2000). High-quality learning and creativity have typically been linked to intrinsic motivation (e.g., Csikszentmihalyi, 1990), and extrinsic motivation has typically been seen as a inferior form of motivation where the action is performed with "resentment, resistance, and disinterest" (Ryan & Deci, 2000, p. 55). Furthermore, incentives such as tangible rewards, deadlines, and competition pressures are thought to undermine intrinsic motivation because they are a way of controlling students' behaviour. Ryan and Deci (2000) found that, if intrinsic motivation is to be held, students must have their needs for autonomy and

competence met, and they need to be interested in the activity. As the students reach secondary school, students become less intrinsically motivated because they become less interested in the activities (McLeod, 1992; Sullivan et al., 2006) and they have less freedom because of social demands and expectations (Ryan & Patrick, 2001). Extrinsic motivation can therefore be fruitful, when the action is performed with “an attitude of willingness that reflects an inner acceptance of the value or utility of a task” (Ryan & Deci, 2000, p. 55).

Intrinsic motivation is part of Csikszentmihalyi’s (1988, 1990) work on flow, that arose from studies into creative and successful people, such as composers, ballerinas, and company directors. He defined a person to be in a state of *flow* when they are in the optimal state of intrinsic motivation and have a balance between their anxiety, arousal, worry, apathy, boredom relaxation, and control, depending on the challenge a task presents and the person’s skill level. When in flow the person is fully immersed in what he or she is doing. They are cognitively efficient and experience pleasure, happiness, satisfaction, and enjoyment because all the contents of their consciousness are in harmony with each other, and with the goals that define the person’s self. When a person is in flow, they are so absorbed that their existence is temporarily suspended. Csikszentmihalyi’s work has been used to some extent in mathematics education, generally in the areas of high achieving students. For example, Leder (2008) used his work to investigate talented mathematics students’ working habits and choices. There is also some resonance between Csikszentmihalyi’s work and the research of Neyland (2004), who introduced the idea of Effortless Mastery. Neyland explored how the unconscious self often provided difficult solutions to a problem without the having to make an effort. According to Neyland (2004), mathematical fluency and intuition – modes of effortless learning that leads to mastery in mathematics – can be compared this to a competent jazz musician where “the hands are not following directives from the conscious mind” (p. 393) but are doing the playing on their own.

Wigfield and Eccles (2000) combined various elements of motivational research by presenting an expectancy-value theory where a student’s achievement related choices, effort and persistence are explained by their beliefs about how well they will do on the activity and the extent to which they value the activity. This theory also included the influence of a number of interrelated factors such as aptitudes, goals, affective memories, and cultural milieu such as gender and cultural stereotypes. What is useful in this theory is it differentiated between external experiences, beliefs and behaviours and the student’s interpretation of these. This differentiation is important – two students that receive the same grade in an assessment

would individually interpret the meaning of this grade, according to their individual expectations of success and other factors individual to themselves.

Students value an activity because doing it will help them fulfil their goals. In other words, students experience a level of motivation, which influences their engagement and depends on their goals (Hannula, 2006). Within the motivational literature students' goals are widely researched and related to their learning and emotions. For example, Dweck (1999) linked students' goals with how students participate in the mathematics and their beliefs about intelligence. In investigating students' perceptions of the extent to which their own efforts influence their achievement in mathematics, she presented two ways intelligence is perceived: as an *entity*, when intelligence is believed to be a fixed trait that cannot be changed; and as *incremental*, when it is believed that intelligence can be cultivated through learning (Dweck, 1999). Students with an incremental view believe intelligence can be increased through effort and guidance, and even if they have *low* confidence in their intelligence thrive on challenge, throwing themselves wholeheartedly into difficult tasks – and sticking with them (Dweck, 1999, p. 3). Students with entity views of intelligence were more likely to choose performance goals whereas those with incremental views were more likely to have mastery goals. Students with *performance goals* want to perform assigned tasks correctly. They seek success by focussing on tasks with which they are familiar – and avoid or give up quickly on tasks that are challenging. They derive their perception of ability from their capacity to attract recognition, often through the endorsement of the teacher. When their effort does not lead to recognition, they feel threats to self-worth. On the other hand, students with *mastery goals* seek to understand the content, and evaluate their success by whether they feel they can use and understand the content. They tend to have a resilient response to failure, they remain focused on mastering skills and knowledge even when challenged, they do not see failure as an indictment of themselves, and they believe effort leads to success (Dweck, 1999).

In mathematics education, Sullivan, Tobias and McDonough (2006) drew on Dweck's (1999) work to investigate students' perceptions of the extent to which their own efforts contributed to their success in, and enjoyment of mathematics. They surveyed and interviewed around 50 students aged 13 years. The interviews were based around six tasks of increasing difficulty for mathematics and another set of six tasks for English. The students were given a new task if they answered the previous one correctly. Therefore, they were challenged at some point in the interview. The students explained their strategies, described their feelings about the challenge, and were asked to give advice to a peer who was potentially a high achiever but did

not try. Unlike the students with performance goals described by Dweck (1999) above, and in contrast to the low levels of persistence and participation reported by their teachers, all the students in this research persevered throughout the interview. They appreciated the importance of effort and persistence for success in mathematics. They demonstrated that they were able to engage fully with the mathematical tasks. Sullivan et al. (2006) concluded that students choose not to engage in class because of the classroom culture, rather than because they are unable to engage. A student's engagement is a result of group and cultural factors as much as individual goals and if the classroom culture censures achievement and effort the students may seek to comply with this culture.

It seems to us that classroom culture may be a more important determinant of participation than the curriculum, methods of teaching, modes of assessment, teacher experience, level of resources, or anything else (Sullivan et al., 2006, p. 97).

This is an important finding and highlights the limitations of studies that view students' learning as a product of individual cognitive processes. Classroom based research is needed to incorporate the social nature of learning and participation. For adolescent students, Ryan and Patrick (2001) described the social environment of the classroom as particularly important in terms of motivation and engagement.

Achievement Goal Theory was developed in Educational Psychology (Pintrich, 2000) to explore both the general and the specific purposes students adopt for their learning. In this conception, students' goals can be separated into task specific goals, such as I should achieve an Excellence for this assessment, and general goals such as a student having a superiority goal or a social goal for friendship. In mathematics education research, Hannula (2006) defined *needs* as the specified instances of the general potential to direct behaviour. Separate from physiological needs, he described needs in an educational setting as autonomy, competency, and social belonging. *Goals* are more specific.

... a student might realize a need for competency as a goal to solve tasks fluently or, alternatively, as a goal to understand the topic taught. A social need might be realised as a goal to contribute significantly to collaborative project work and a need for autonomy as a goal to challenge the teacher's authority (Hannula, 2006, p. 167).

According to Hannula (2006), Op't Eynde et al.'s (2006) concept of identity is similar to this conception but includes needs and goals in a single system, that of desired identity.

Hannula (2006) found that students experience tension when there is conflict between their differently dominating needs. The student can enact these tensions in a negative way, such as through challenging the authority of the teacher, or by conforming to peer-pressure to under-perform. Furthermore, depending on whether a situation is in line with their motivation and/or needs and goals, people experience positive or negative emotions (Hannula, 2006). This link between motivation, goals, and emotions is well known. For example, Csikszentmihalyi (1988) viewed emotions as being an integrated response to goals that make up a person's self. Malmivuori (2006) similarly discussed how students' "powerful emotions" are linked to their "personal and situation-specific appraisals of the self with respect to their goals and effort in the math classroom interactions" (p. 151). In Phase Two, Mandler (1989) also connected emotions to students' needs and goals. He described emotions as occurring when there is a discrepancy between the individual's expectations and the demands of an ongoing activity.

Emotions, introduced in section 2.2, are considered critical to academic settings because they are strongly linked to students' academic engagement (Linnenbrink-Garcia & Pekrun, 2011). Research into emotions varies according to the level emotions are being assessed at – whether emotions are specified using for example, facial expressions or physiological responses, or whether emotions are described more generally as pleasant or unpleasant affective states. Researchers also vary on whether they focus on emotional states, which fluctuate from moment to moment, or whether they focus on longer-lasting emotional traits "reflecting individuals tendencies to respond in a certain manner" (Linnenbrink-Garcia & Pekrun, 2011, p. 1). Pekrun (2006), extending an earlier theory into anxiety, introduced the control-value theory of achievement emotions for analysing emotions experienced in academic contexts, both when doing an activity (activity emotions) and in anticipation and as an outcome of the activity (outcome emotions). He viewed *emotion* as a psychological process with multiple components. For example, anxiety includes nervousness (affective component), worry (cognitive component), avoidance motivation (motivation component), anxious facial expressions (expressive) and peripheral physiological activation (physiological) (Pekrun, 2006). Unlike the research in Phase Two, Pekrun (2006) also included low-intensity emotions in his theory of emotions, which he calls 'moods' although he acknowledges moods are not necessarily represented in conscious awareness (Pekrun, 2006).

In Phase Two, McLeod described an individual as having a range of affective responses to mathematics of different stability, which he categorised into beliefs, attitudes, and emotions.

Indeed, researchers have various ways of differentiating between task-specific emotions and more general feelings. For example, Pekrun (2006) separates emotions into state emotions (the momentary occurrences of emotions within a given situation at a specified point of time) and trait emotions (habitual recurring emotions typically experienced by an individual in relation to achievement activities and outcomes).

In mathematics education, Goldin (2002, 2004), later working with DeBellis (2006), proposed dividing affective responses into *local* and *global* affect. *Local affect* was defined as changing states of emotional feelings during mathematical activity which, when established and recurrent, formed *affective pathways*. This is a similar conception to students being described as having habitual behavioural patterns in mathematical situations as in Malmivuori's (2006) research. DeBellis and Goldin (2006) differentiated between a positive affective pathway and a negative pathway. A positive affective pathway was one where the student began by experiencing curiosity and puzzlement if the problem was unfamiliar and difficult. This motivated the learner to better understand the problem. As the problem solving continued, the person went through a stage of bewilderment and frustration, which carried the meaning that the strategies employed so far had led to insufficient progress. One or more changes of strategy eventually yielded pleasure and satisfaction. In a negative pathway, frustration did not lead to a change of strategy and ended in the individual experiencing anxiety and despair, which evoked avoidance strategies and defence mechanisms. DeBellis and Goldin (2006) characterised a person as having *affective competencies* – the individual's capabilities to encode their affect and to respond with action that enabled them to complete the problem. In their conceptualisation, affective pathways lead to the construction of *global affect*, which is a more stable, longer-term structure which establishes further contexts for local affect (DeBellis & Goldin, 2006). DeBellis and Goldin (2006) were focussed only on problem solving. Despite this, the constructs of local and global affect and affective competencies seem useful, and are explored further in section 6.1. Not only do these constructs incorporate a dimension of stability, they describe the mechanism for changing between emotions and longer-term affective structures. Unlike McLeod's conception, which defined an individual's emotion as an intense affective response, this conception of local and global affect does not preclude a range of intensities of affective response.

In the research in Phase Three, it is generally understood, that, whether positive or negative, when a person participates in a mathematical task, they experience affect which meaningfully encodes information for them about their progress in the task (Brown & Reid, 2006; DeBellis

& Goldin, 2006; Goldin, 2002; Malmivuori, 2006; Op 't Eynde et al., 2006). When a person experiences frustration, for example, this affective response may represent a lack of progress towards their goal. Joy may encode that they have reached their goal (DeBellis & Goldin, 2006). This affective information activates various appraisal and self-regulatory processes (Malmivuori, 2006).

Self-appraisals are also an important determinant of human emotions, according to Pekrun (2006). He introduced the control-value theory, which posits that two groups of appraisals are of relevance to achievement emotions “(1) subjective control over achievement activities and their outcomes (e.g., expectations that persistence at studying can be enacted, and that it will lead to success); and (2) the subjective values of these activities and outcomes (e.g. the perceived importance of success).

These are the processes where an individual appraises the situation according to their relationship with mathematics and acts according to these appraisals and the current context of the learning situation. This process results in unique mathematical learning experiences and performance outcomes.

Radford (2008) critiqued the idea of a learner constructing his or her own knowledge through self-regulation. This view is problematic because students are assumed to “naturally [act] in a scientific, rational mindful manner” (p.216) – individuals who know their business and are able to self-regulate. Indeed, both Malmivuori (2006) and DeBellis and Goldin (2006) described students as having varying degrees of competency at self-regulation. DeBellis and Goldin, for example, described a student’s *affective competencies*, which refer to the capabilities of an individual to make effective use of affect during mathematical activity. This awareness of affect, or *meta-affect*, is defined as “affect about affect, affect about and within cognition ... and/or further affect” (DeBellis & Goldin, 2006, p. 136). Some students, for example, take frustration as a signal to modify strategy, rather than give up (DeBellis & Goldin, 2006). A student’s affective competency is an interesting concept, although there are many more factors in students’ problem solving behaviour, such as the learning situation, that also need to be considered. Of course, students’ self reflection and self-regulation depends on the degree of awareness, or consciousness, they have about their affective processes.

Different researchers vary according to their view of the relevance and importance of students’ unconscious selves. Csikszentmihalyi (1988) argued researchers who are particularly interested in the scientific method often develop reductionist accounts of human action that discount or ignore the existence of a conscious self. Conversely, in the affective

domain, it seems the unconscious self is the one that is often discounted by researchers (Murphy & Alexander, 2000).

In this thesis, students are viewed to have complex, interacting, and dynamic affective processes that occur at different levels of consciousness. Students are conscious of some of the affective processes they experience during mathematical activity. For example, a student's attitude to mathematics – whether they like or dislike the subject – is consciously felt (Malmivuori, 2001). In contrast to these and students' more active and conscious cognition, many of the mental processes behind their affect are inaccessible, unconscious or *preconscious* (DeBellis & Goldin, 2006; Malmivuori, 2001). The term 'preconscious' applies to thoughts that are unconscious when they occur, but are available for recall and can become conscious. For example, a student's goals (Pintrich, 2000) and emotions (Malmivuori, 2001) are described as preconscious. Cognitive theories of motivation assume that students make conscious choices about when to work and when not to work (Kloosterman, 2002). However, Hannula (2006) argued that motivation has the element of the unconscious and he cautioned against researching students' motivation without acknowledging the unconscious self because of its importance in understanding the link between affect and cognition. Malmivuori (2001) considered that the depth, stability and importance of pupils' mathematical beliefs are linked to the degree of consciousness of these beliefs. Students' most stable beliefs are only weakly conscious, yet these are often the most interesting beliefs for affective researchers to study because they are the beliefs the strongest affect is linked to. Only the affective response or arousal with these kinds of beliefs may be experienced, and not the content of a belief as such (Malmivuori, 2006).

Being able to *get at* the whole range of students' conscious, unconscious, and preconscious affective processes and being able to ensure data collected adequately reflects students' true selves is methodologically challenging (Murphy & Alexander, 2000). Students affective processes cannot necessarily be reflected on and communicated to others and is a phenomenon only partially accessible to introspection. This methodological difficulty contributes to why researchers in mathematics education have traditionally studied affective responses that have a low intensity, high stability, higher controllability, and higher involvement of conscious cognitive processes (Malmivuori, 2001). For example, many researchers focus on students' conscious reflections on their likes and dislikes of mathematics. Research in educational psychology generally relies on self-report or self-perception measures to ascertain participant's motivations (Murphy & Alexander, 2000). This is fine if students are

conscious of their motivation. Hannula (2006) contended that inferences of the unconscious and subconscious in motivation can be made from behaviour because it is “always a dependable manifestation of motivation” (p. 167), even when a person is unable to explain their behaviour. He explained that a person’s emotions are the most direct link to understanding their motivation. Depending on whether a situation is in line with their motivation, people experience positive or negative emotions (e.g. joy, relief, anger, frustration). These emotions are partly observable but partly unobservable subjective experience. DeBellis and Goldin (2006) also infer internal affect from external observable behaviour, such as facial expressions, in individual children’s’ mathematical problem solving.

Evans (2000) explored factors of students’ unconscious affective processes through collecting data about their emotions. He described the way emotions with strong negative charges, such as anxiety, “tend to meet defenses, and to be pushed into the unconscious through the operation of repression” or other defense mechanisms (p. 113). He reasoned that when a student represses negative emotion, when these ‘return’ to consciousness, “they retain their charge but tend to be found in a disguised or distorted form, for example, as jokes, or ‘slips’ of the tongue” (Evans, 2000, p. 113). Evans, later with Morgan and Tastsaroni (2006) suggested a discursive approach to tap these repressed affective processes using textual analysis that focused on the exchange of meanings between students. In their data, they sought the following indicators of emotions:

- Direct verbal expression, e.g., I feel anxious
- Use of particular metaphors, e.g., claiming to be coasting
- Emphasis by words, gesture, intonation, or repetition, indicating strong (or chronic) feelings
- Body language, facial expression or blushing
- ‘Freudian slips’ or jokes
- Denial of emotions, for example, anxiety
- Behaving strangely
- Impatience to get/know the ‘right answer’
- Identification where students seek to take on characteristics of an admired teacher or classmate
- Resistance to authority figures, including peers (Evans et al., 2006, p. 214).

### 2.3.3 A mathematical core

There is some agreement in the literature that students have a complex *mathematical core* – a term introduced in this thesis to refer to an individual’s stable internal structures which relate to mathematics. These cores work as part of the context within which students learn (DeBellis & Goldin, 2006; Malmivuori, 2006; Op 't Eynde et al., 2006). These cores however have different components and researchers using this idea conceptualise learning differently.

Op 't Eynde et al. (2002, 2006) objectify a student’s mathematical core, calling it identity (2006) – “who they are” (p.194) or earlier, mathematical disposition (Op 't Eynde et al., 2002). DeBellis and Goldin (2006) described a person as constructing *global affective structures*, which encompass values, beliefs, and attitudes and affective pathways. Malmivuori (2001, 2006) called this core a student’s *self-system* and details similar components as DeBellis and Goldin (2006).

Many of the researchers objectify a student’s core and imply structure. In this sense there is an element of stability in their conception of a student’s mathematical core. Similar to the way beliefs were said to be dynamic in Phase Two, the researchers conceptualise the elements of the cores to be dynamic to different extents. Generally, new learning experiences are thought to, either reinforce them or, if sufficiently powerful or repeated often enough, alter them. The development of these mathematical cores are also described to different extents but are generally thought to develop from students’ sociocultural backgrounds and previous learning experiences. For example, according to Malmivuori (2001, 2006), elements in students’ mathematical cores develop from students’ previous experiences with mathematics in social environments. New, important or personally significant mathematics learning experiences further build up or modify these structures.

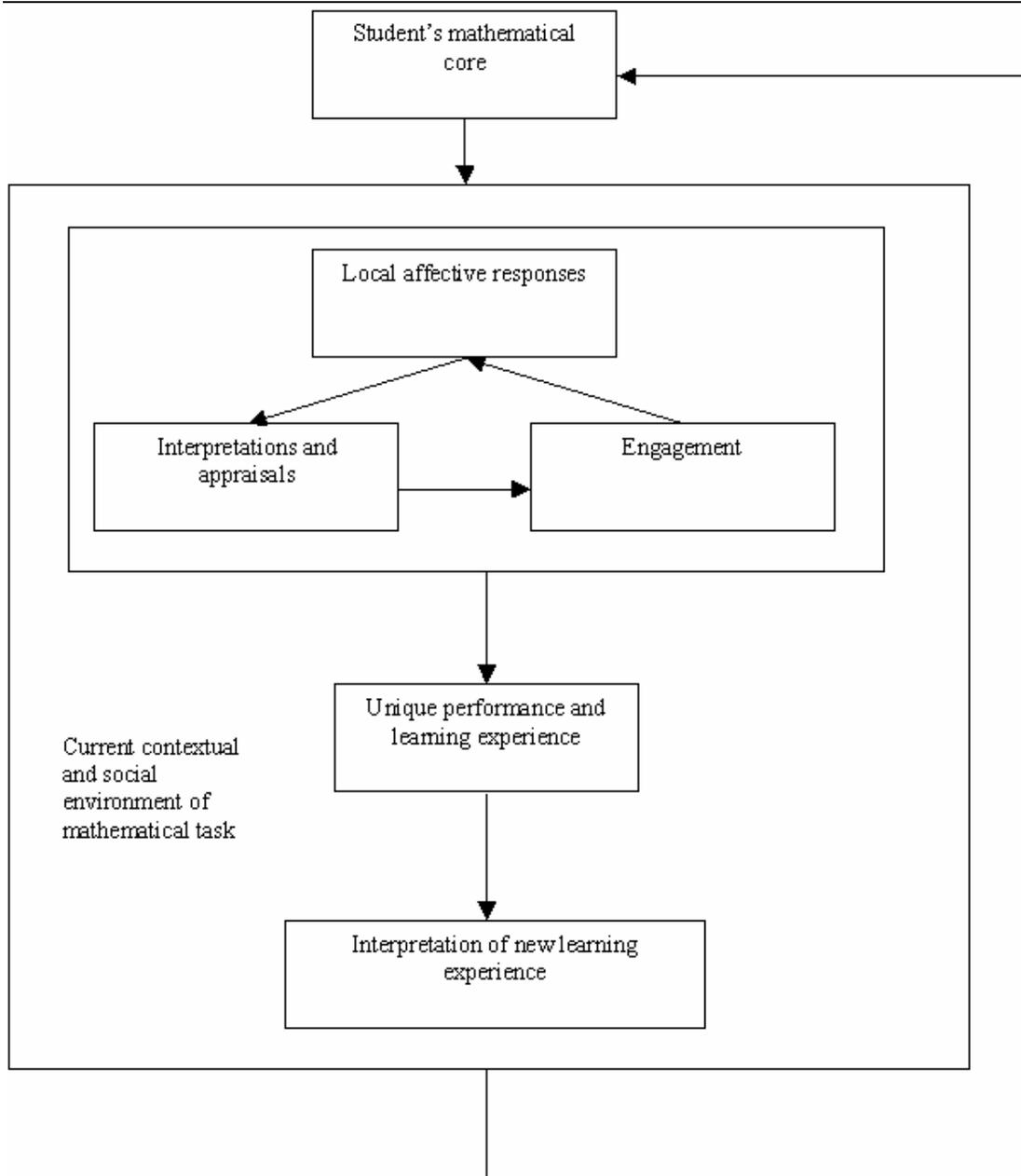
Csikszentmihalyi (1988, 1990, 1997) talked about students having a structured self with central goals. Csikszentmihalyi’s insight was that, rather than pursue happiness, people should recognise when they are genuinely happy and do more of those things (Butler-Brown, 2006). Because the tendency of the self is to reproduce itself, and because the self is most congruent with its own goal-directed structure during these episodes of optimal experience, to keep on experiencing flow becomes one of the central goals of the self” (Csikszentmihalyi, 1988, p. 24). Each self develops its own hierarchy of goals, which become part of the structure of that self. Whenever a new experience enters consciousness, it is evaluated in terms of the goals

that reflect the self, and it is dealt with accordingly. Pintrich (2000) similarly talks about achievement goals representing a general orientation to the task that includes a number of related beliefs about purposes, competence, success, ability, effort, errors, and standards

From the literature therefore it seems that students have an inner mathematical self. Each researcher has theorised aspects of this self separately or attempted to bring it under one label, such as general orientation (Pintrich, 2000), or global affect (DeBellis & Goldin, 2006). A very broad conception is needed because of the sheer complexity and interaction between a student's motivations, needs, feelings, beliefs and other affective components. A student's mathematical self is defined in this thesis as their *mathematical core*. A student's mathematical core consists of a structure of elements that form a relationship between the student and mathematics and that form part of the context within which they learn.

- Mathematical content knowledge such as the facts, symbols, concepts and rules that constitute the contents of mathematics as a subject field (Malmivuori, 2006);
- Strategies for accessing and using the content knowledge to solve mathematical problems (Op 't Eynde et al., 2006);
- Beliefs about mathematics which incorporate students' personal, internal and shared subjective conceptions about mathematics, mathematics teaching and learning, about themselves in relation to mathematics, and about the context (Malmivuori, 2006);
- Related goals (Csikszentmihalyi, 1988; Pintrich, 2000) and needs of autonomy, competency, and social belonging (Hannula, 2006);
- Global affects (DeBellis & Goldin, 2006);
- Meta-knowledge which involves knowledge about meta-cognitive functioning and knowledge about affect and its use (Malmivuori, 2006);
- Habitual affective pathways and behaviours in mathematics, including affective skills (DeBellis & Goldin, 2006).

The nature of students' mathematical core and its association with the learning process, according to the affective literature, is summarised in Figure 2.4 below.



**FIGURE 2.4 Students' learning according to the affective literature**

In summary, Figure 2.4 shows that, according to the affective literature in mathematics education, student's mathematical learning has five main components that interact with each other in a complex way. Students interpret the mathematical situation according to the context and their mathematical core. As a result they experience a wide range of unique local affective responses to mathematics. The responses can be unstable, hot emotions, with accompanying physiological arousal such as anxiety or joy, or they can be less hot responses such as boredom or interest. These affective responses provide information for the individual about their progress towards their needs and related goals and may disrupt or distract the

learning process and affect the level of capability while performing mathematics. The information activates self-appraisals, which thus determine how a student approaches the mathematical task, depending on their current level of awareness, control and regulation capacities. These processes result in unique performances and new learning experiences. These experiences are further interpreted in relation to the student's mathematical core. Although these learning experiences are social in that meaning is jointly constructed in the community of the mathematics classroom, they are also individual because of the interplay between these processes, students' unique affective responses, and their mathematical core. Students' interpretations of their experiences, in turn, reinforce or alter their dynamic core.

## 2.4 Conclusion

This chapter has explored the different ways students' mathematical affect has been conceptualised and the different ways it has been related to learning. Many researchers in the affective domain use achievement as an indicator of learning. Other researchers use indicators of learning such as researcher or teacher observations of students' behaviour. Indeed affective research describes a multitude of observable behaviours in mathematics that are implied to be indicators of learning, including avoidance of mathematics, choosing not to continue with the field (Betz, 1978; Greenwood, 1984; Hembree, 1990; Hendel & Davis, 1978; Schoenfeld, 1985), and poor classroom behaviour (Reyes, 1984). These do not capture the connection between affect and students' learning processes from the students' perspective and do not capture the social aspects of learning mathematics.

The affective literature in Phase Three has gone some way to connect affect with learning. Some of the research reviewed in this phase had in common the concept of a student having a mathematical core – structural components of mathematical content knowledge, strategies, beliefs, needs, global affects, meta-knowledge, and habitual affective pathways and behaviours. The research in this phase described in detail how elements in students' mathematical core change as they experience mathematics. Again, with few exceptions (e.g., the longitudinal work of Hannula, 2002, 2006), what is missing from this literature is how the students' perceive their affect to be associated with their learning and how these continue to interact over their mathematical journeys. Op't Eynde et al. (2006) connect affect and mathematical identity. It is the similarity between the notions of a student having a mathematical core and ideas of mathematical identity that I wish to pursue in the next chapter.



## CHAPTER THREE: Identity

In this chapter, I examine students' relationships with mathematics through identity research. Affect was theorised in Chapter Two as forming part of students' mathematical cores and thus contributing to students' learning processes. A student is thought to appraise their progress in mathematical activity according to elements of their mathematical core (section 2.3) and this affects their behaviour and performance outcomes in mathematics. A student's mathematical core could also be conceptualised as their 'mathematical identity' and it is the notion of identity that is explored in this chapter.

Similar to the elements of the affective domain reviewed in Chapter Two, there are different conceptions of identity in the literature and it is, at times, not defined sufficiently or given adequate explanation (Gee, 2000-2001; Sfard, 2008). Identity is variously seen as a person's attributes such as ethnicity, gender, or social ranking (Vaughan & Hogg, 2005), who one is (Op 't Eynde et al., 2006), self-concept (Owens, 2003) or a narrative or story about a person (Kaasila et al., 2005; Sfard & Prusak, 2005a). In this chapter, these different perspectives of identity are contrasted by discussing whether identity is an individual or social phenomenon, whether multiple identities exist, the stability of the concept, and how identity relates to learning processes. In contrasting these perspectives, the notion of a student possessing a mathematical core is critiqued, and further understanding of students' mathematical journeys is discussed.

### 3.1 Individual and social identity

Similarly to the discussion of learning in the affective literature in Chapter Two, identity has been conceptualised as individual or social or some combination of both. These differences are critical in how previous research in mathematics education has been conceptualised. In this thesis, identity is viewed as the connection between the individual and the social and this section clarifies and discusses this view.

In mathematics education research, identity has generally been viewed as an individual phenomenon (Lerman, 2001; Nasir, 2002). Identity has been connected to notions such as self-concept, self-worth and self-efficacy and is largely seen as constituted through individual appraisals of new learning experiences (e.g., McFeetors & Mason, 2005). Even when

individuals are conceptualised as operating in groups, these groups are considered to be made up of individuals who interact with one another, rather than individuals who have a collective sense of shared identity (Vaughan & Hogg, 2005).

Other researchers see identity formation as neither an individual nor a social phenomenon. Holland et al. (1998) described identity as “a way of naming the connections between the intimate and public sites of social practice” (p. 175). Sfard, with Prusak (2005a, 2005b), described identity to be the conceptual link between the collective and the individual.

It is in the attempts to fathom the mechanisms of these collective-to-individual and individual-to-collective transformations that the notion of identity ... comes to the fore as perhaps the best candidate for the part of a linkage between what is happening at the personal and interpersonal levels. ... Its dynamic dimension, its being susceptible to collective moulding, on the one hand, and its effectiveness in shaping individual doings, on the other hand, make identity the principal carrier of the relevant changes (Sfard, 2006, p. 23) from one form of activity to another, and from discourse to discourse (Sfard, 2008, p. 291).

Wenger (1998), in his conceptualisation of communities of practice described in section 2.3, also eschewed any conflict between the social and the individual in identity work.

The concept of identity serves as a pivot between the social and the individual, so that each can be talked about in terms of the other ... It does justice to the lived experience of identity while recognising its social character – it is the social, the cultural, the historical with a human face (Wenger, 1998, p. 145).

In this view, students create and co-construct their environment (Perry, Turner, & Meyer, 2006) and are also products of their environment, incorporating these “essential understandings, practices, and mores of particular contexts into their thinking and behaviour” (Perry et al., 2006, p. 332). Students attempt to make sense of the community of the mathematics classroom (Wenger, 1998) and acquire a sense of who they are as learners of mathematics (Boaler et al., 2000b). In this view, as students participate in the practices of the community in increasingly substantial ways, they are negotiating the meanings of their experience of membership and therefore are constructing identities (Hodge, 2006).

[Students] are compelled to sit in a mathematics classroom for a significant period of their school life, they come to learn how to participate in that context – they learn when to respond, when to resist, how to appear busy but avoid work. They learn how to cope with the embarrassment, the joy, the cajoling. They learn how the actions in the classroom have meaning and how some of the actions of teachers, texts and students take on substantially different meanings for themselves and others. They learn how to *be* a mathematics student. They develop a sense of who they are as learners within this context (Boaler et al., 2000b, p. 5).

Many of the conceptions of a mathematical core in section 2.3 were concerned with individuals' constructing the elements through individual processing of their learning experiences. However, learning is conceptualised more appropriately as a social phenomenon. The elements of a student's mathematical core – the student's mathematical knowledge, strategies, beliefs about mathematics, needs, global affects, meta-knowledge, and habitual affective pathways and behaviours (section 2.3) – need to be viewed as both collectively and individually constituted through participation in the shared practices of the mathematics classroom.

## **3.2 Multiple identities**

If identity formation is not conceptualised as a wholly individual phenomena, then people can have membership in multiple communities of practices and therefore multiple identities (Boaler, 2002a; Boaler & Greeno, 2000; Boaler et al., 2000b; Forster, 2000; Hodge, 2006; Hodgen & Askew, 2007; Kaasila et al., 2005; Solomon, 2007). In this thesis, students' identities are conceptualised as having multiple aspects. Students are participants in other communities of practice apart from and within the mathematics classroom. A student's home and extended family form other communities, as do their sports teams, friendship groups and employment. There may also be communities within the mathematics classroom. A particular social group may have its own set of practices. Identities form as students individually negotiate the meaning of their participation in the community (Hodge, 2006). Individuals therefore could be seen to have identities as mathematical thinkers, as social members of classroom, as members of sports groups, and members of the wider communities of school, home and society. Wenger (1998) viewed identity as a nexus of multi-membership in different communities.

This nexus of multi-membership can have tensions as students continuously seek to integrate the experiences they have in different communities (Op 't Eynde, 2004). Students, particularly adolescents, are in the midst of pressures to negotiate their lives through their many identities (Hodgen & Askew, 2007).

Confronted by tensions between the different aspects of their identities, individuals are compelled to negotiate and reconcile these different forms of participation and meaning in order to construct an identity that encompasses the membership of different communities. This process of identity reconciliation is central to an individual's ability to make connections and transfer meaning and knowledge between practices (Hodgen & Askew, 2007, p. 473).

This concept of a student having multiple and sometimes conflicting aspects to their identities is partly accounted for in the affective literature. Detailed in Chapter Two, Hannula (2006) described how students have various needs such as autonomy, social belonging, and competency. Students experience tension internal to the individual when they experience conflict between differently dominating needs. In Chapter Two, Skemp (1976) and Dweck (1999) described tensions when students' goals are different from the teachers. Lerman (2001) suggested there is a need to understand how these tensions affect a student's mathematical learning processes. It is quite likely that these tensions affect a student's mathematical journey over time, so it is important, therefore, to compare the different conceptions of how students' identities change.

### **3.3 Stability of identity**

How stable identity is viewed to be often depends on a researcher's definition of the construct. Identity can be broadly defined from the psychological perspective, which relates traits or unique identifiers to major structural features of society such as ethnicity or gender; categories people use to specify who they are, to locate themselves relative to other people, and present themselves to the world (Owens, 2003). Identity is seen as stable in this perspective – a stable set of attributes of the student, rather than constantly forming through participation in social practices. In other words a person's identity is unaffected by social interaction or learning. In mathematics education, Grootenboer, Smith and Lowrie (2006) also suggested identity to have an element of stability, defining identity as:

How individuals know and name themselves (I am: a teacher, a student, good at maths) and how an individual is recognised and looked upon by others (that person is: white, tall, smart, an introvert) (Grootenboer et al., 2006, p. 612).

What Grootenboer et al.'s (2006) interpretation has in common with the psychological tradition is it recognises that identity is made up both of students' own interpretations of themselves and other people's interpretations through categorisations. A student naming themselves as good at maths is the objectification of that interpretation, and with role, height, nationality and personality, perceived as relatively stable. Using aspects of social structure such as class, nationality, or gender in research to define a person is fundamentally suspect. It ensures that a student is forced to adopt a set of assumed characteristics relating to their categorisation. These social categorisations do not exist in an objective way. That is not to say that culture or gender patterns or tendencies do not exist in mathematics education. The experiences that individual students have in different cultural contexts have a profound effect on their learning, but these cannot be assumed from simply categorising a student because they fail to account for individual differences (Skovsmose, 2005b).

Other researchers have a more dynamic view of identity. Echoed by Op't Eynde et al. (2006) in mathematics education, Wenger (1998) viewed identity as dynamic; as a constant becoming of who one is in a particular social context. Even more dynamically, identity research from a poststructuralist perspective surrounds issues of power, relations and positioning, and the political and institutional processes central to the constitution of the self (Walshaw, 2004a). Researchers with this perspective do not engage in the "common quest of uncovering one's true identity or self" (Walshaw, 2004a, p. 66) and see identity as dynamic and unstable and developing through social and cultural practices (Grootenboer et al., 2006). Similarly, in the concept of a figured world (Holland et al., 1998) described in Chapter Two, a person's identities develop through continued participation in the positions defined by the social organisation of activity and therefore their identities are dynamic and unfinished, improvised within the activity of social situations and using the cultural resources at hand. Identity is seen as a dynamic and historical product, which is malleable when exposed to "whatever powerful discourses they happen to encounter" (Holland et al., 1998, p. 27).

[A person is] caught in the tensions between past histories that have settled in them and the present discourses and images that attract them or somehow impinge upon them ... the person acquires the ability to take the standpoint of others as she learns to objectify herself by the qualities of her performance in and commitment to various

social positions ... such objectifications, especially those to which one is strongly emotionally attached, become cores of one's proactive identities (Holland et al., 1998, p. 4).

Sfard and Prusak (2005a, 2005b)'s view of identity was powered by their investigation into the differences in mathematical learning processes between immigrant students from the Soviet Union and native Israelis in a mathematics class of 19 students. The research was conducted by the teacher (Prusak) observing the class, and through extensive interviews with the students, their teachers and parents. A focus of this investigation was how sociocultural aspects seemed to factor into learners' individual activities. Sfard's (2008) further scrutiny of research centred on aspects of definition. A particular strand of the discussion is people's tendency towards *objectification*, which turns "statements about processes into impersonal statements about objects" (p. 63). An example of the process of objectification would be reducing 'Mark tends to do well in mathematics tests' to 'Mark is good at mathematics'. Although objectification leads to more efficient communication, the use of such "low resolution" (p. 64) objectification has repercussions.

Objectified descriptions of human phenomena gloss over important inter-personal and intra-personal differences ... and produce diagnoses and evaluations that function as self-fulfilling prophecies (Sfard, 2008, p. 64).

For example, if a teacher says 'Mark is good at mathematics' elaborating that this pertains to his tendency to do well in mathematics tests, then Mark's success is objectified as a reality about him as a person, for Mark, his parents, other teachers and researchers. Information is lost. It may be he performed well once on what was considered to be an important assessment rather than achieving success on a wide range of assessments or tasks. It may be that he is perceived to be good at mathematics by being often first to finish a task. It may be because he conforms to the behavioural expectations of the class. It may be that he is innovative in his problem-solving through the use of a range of strategies. It may be that, because his teachers or peers consider him good, he gains confidence in his ability to perform and engages more fully in the task. In turn, he performs well and reinforces the notion that 'Mark is good at mathematics'. *Is* sentences have a reifying effect because they transform the properties of the subject's actions into properties of the subject himself.

Sfard and Prusak (2005a, 2005b), disputed any process of objectifying the construct of identity, or defining it as who one is, and they rejected the notions of "God-given"

personality, character, and nature; essentialist visions of identity, which “seem to be saying that there is a thing beyond one’s actions that stays the same when the actions occur” (Sfard & Prusak, 2005b, p. 15). Consequently, Sfard and Prusak (2005b) critique notions such as beliefs and attitudes discussed in Chapter Two, despite their tempting capacity to “compete with identity for the role of conceptual bridge between learning and its cultural setting” (p. 15). In Chapter Two, when students are described as having a belief or an attitude this is often an essentialist vision of beliefs and attitude. In other words, they are assumed to have a discourse-independent existence. Sfard and Prusak critiqued this research as not being operational because it is unclear in the research how one is supposed to get hold of a person’s beliefs or attitude given they are not objects but dynamic and dependent on the current context. For them, constructs such as personality, with other social categorisations such as ethnicity, are flawed. When a student experiences a new learning situation and as a result of their interpretations acts in a certain way, there is, at some level of consciousness, an element of appraisal. Sfard’s notion is that nothing stays the same when an action occurs. Rather than discussing students’ beliefs about mathematics, it is important that the students’ views about mathematics are described. This change is to reflect a divergence from the belief literature. A student’s views about mathematics are socially constructed and dynamic and are part of their mathematical core.

This is an important point because it reinforces that a student’s mathematical core is dynamic – constantly changing through participation in the mathematics classroom. The meaning constructed from students’ interpretations of their learning experiences and performances either reinforce or alter its elements. The way a student approaches each unique mathematical situation is therefore a complex mix of history and the present, stability and instability. A student’s mathematical core, is therefore re-negotiated during every learning experience in the classroom. Consequently, I consider that the term ‘mathematical core’ is too static to describe this process, and instead it will now be referred to as a ‘student’s relationship with mathematics’. Therefore, a student’s *relationship with mathematics* is the dynamic connection between the student and the subject of mathematics.

### **3.4 Identity as a narrative**

Researchers who view identity to be a narrative add to understanding about how students’ relationships with mathematics change as a result of their participation in the mathematics classroom and other communities they participate in. Bakhtin (1981) explained that

communication is socially constructed because it represents how people live with each other in a social world. Discourse is “gradually and slowly wrought out of others’ words that have been acknowledged and assimilated” (Bakhtin, 1981, p. 345). Holland et al. (1998) described socially-constructed self-understandings which are activity based around communication.

People tell others who they are, but even more important, they tell themselves and then try to act as though they are who they say they are. These self-understandings, especially those with strong emotional resonance for the teller, are what we refer to as identities (Holland et al., 1998, p. 3).

Following their critique on affective and identity research, Sfard and Prusak (2005a, 2005b), developed a narrative approach to identity and view identity formation to be a form of communicational practice. In Sfard and Prusak’s (2005a, 2005b) approach, *identities* are the stories that surround a person.

No, no mistake here: We did not say that identities were *finding their expression* in stories – we said they *were* stories (Sfard & Prusak, 2005b, p. 14).

Therefore no entity stays the same when the stories themselves change. An identity researcher is interested in “the stories as such, accepting them for what they appear to be: Words that are taken seriously and shape one’s actions” (Sfard & Prusak, 2005a, p. 51). These stories perform the process of identifying (or subjectifying), which is a special case of the activity of objectifying, one that occurs when the discursive focus shifts from actions and their objects to the performers of the actions. Translating stories of processes into stories of states can create a sense of stability and permanence.

Our relations with the world and with other people change continually, sensitive to our every action. Metaphorically speaking, identifying is an attempt to overcome the fluidity of change by collapsing a video-clip into a snapshot (Sfard & Prusak, 2005b, p. 16).

Sfard and Prusak (2005b) acknowledged this seems reductionist and that this idea moves away from Wenger’s view, which describes words as “not the full, lived experience of engagement in practice” (Wenger, 1998, p. 151). Sfard and Prusak (2005b) countered this.

Although we agree that identities originate in daily activities and in the “experience of engagement”, it would be a category mistake to claim that this fact disqualifies our narrative rendering of identity. Indeed, it is our vision of our own or other people’s experiences and not the experiences as such that constitutes identities ... they are discursive counterparts to one’s lived experiences (Sfard & Prusak, 2005b, p. 15).

Sfard and Prusak (2005a, 2005b) and later Sfard (2008), equated identities to be those stories surrounding a person which are:

- **Reifying** – the transformation of an action into a state which suggests repetitious behaviour through the use of the verbs *be*, *have*, *can*, and the adverbs *always*, *never*, *usually*.
- **Endorsable** – the identified person (the person the story is about) endorses that the story reflects the actual or expected state of affairs.
- **Significant** – if any change in it is likely to affect the storyteller’s feelings about the identified person particularly with regard to membership of a community.

A person has a number of stories told about them by multiple narrators, including themselves. Identities are products of what Sfard and Prusak call *discursive diffusion*, where individual and communal stories from different narrators and for different audiences are interpreted, fine-tuned, and recycled as new stories. *Stories* consist of a person’s self-dialogue (thinking), spoken-out-loud stories about themselves or other people, stories told about them by other people, interactions with other people, and reactions to events. There are also those stories told about that person by other narrators. Identities, according to Sfard and Prusak (2005a, 2005b) also included extra-discursive (or mind independent) stories, such as examination results, certificates, and report grades, referred to as *institutional narratives*. Sfard and Prusak (2005a, 2005b) described these stories as having a powerfully reifying effect on the student with “a particular capacity to supplant stories that have been a part of one’s designated identities” (Sfard & Prusak, 2005b. p. 18).

Sfard and Prusak (2005a, 2005b) divided a person’s multiple identities into two sets of identities. *Actual identities* are attempts to overcome the fluidity of change by freezing the picture (Sfard & Prusak, 2005a, 2005b). These stories are factual assertions about a person, and can be identified by the use of *I-am* or *he-is* sentences told in the present tense, such as ‘I am bad at maths’ or ‘He is a good mathematician’. *Designated identities* – ‘I should be’

stories – have the potential to become part of one’s actual identity, and influence one’s actions to a great extent.

The scenarios that constitute designated identities are not necessarily desired, but are always perceived as binding. One may expect to “become a certain type of person”, that is, to have some stories applicable to oneself for various reasons: because the person thinks that what these stories are telling is good for her, because these are the kinds of stories that seem appropriate for a person of her sociocultural origins, or just because they present the kind of future she is designated to have according to others, in particular to those in the position of authority and power (Sfard & Prusak, 2005a, p. 45).

Sfard and Prusak linked their notion of identities with a student’s affective responses in mathematics. When there is a perceived and persistent gap between a student’s actual and designated identities, Sfard and Prusak (2005a, 2005b) suggested there is likely to be a sense of unhappiness in that person. ‘Unhappiness’ suggests a global affect, as described by DeBellis and Goldin (2006), with little intensity. However, for narratives that are especially important to a person, this emotion will be amplified. In Sfard and Prusak’s (2005a) research, the students from the Soviet Union needed mathematical fluency in order to close the critical gap between their actual and designated identities, and therefore had strong, negative emotions when they did not achieve. The Israeli students had much less learning-fuelled tension when they did not achieve because any lack of mathematical skills did not contribute to a critical gap between their actual and designated identities. Their need for mathematical fluency was not as strong. The affective literature describes a student as having a full range of emotions and feelings of different intensities and stability, ranging from positive to negative (McLeod, 1992). According to Hannula (2006), and discussed in detail in section 2.3, depending on whether a situation is in line with their needs and goals, people experience positive or negative emotions. In other words, when a person is meeting their needs and goals they experience positive emotions. On the other hand, Sfard and Prusak (2005a, 2005b) only viewed feelings of unhappiness as being of interest because this feeling was likely to lead to a closing of the gap between actual and designated identities through learning.

Learning is our primary means of making reality in the image of fantasies ... with their tendency to act as self-fulfilling prophecies, identities are likely to play a critical role in determining whether the process of learning will end with what counts as success or with what is regarded as failure (Sfard & Prusak, 2005a, p. 47).

Sfard and Prusak (2005a, 2005b) said that it is identities that shape a person's actions. More specifically, it is the gap between their actual and designated identities that do so, because that provides the tension.

Sfard and Prusak's (2005a, 2005b) research is useful and their conception has been used in this thesis because of the links that have been made between affect, learning and identity. It also contributes to research being operational by being based around what students say, rather than on the researcher or teacher's perceptions of what is going on in the classroom. However, although it is clear that a person's identities are constantly changing through their interactions with themselves and others it is unclear if there is any stability in identities over time, and this is a need for further research into this.

The literature surrounding affect led to the notion of students having a relationship with mathematics. Viewing identity as a narrative does not discount this view. Rather, students' narratives are the lived experience of their relationship with mathematics. It is not the learning experiences or students' behaviour that matters in understanding students' journeys. It is the students' self-understandings; their personal interpretations of themselves and their learning experiences that occur within their cultural contexts that are important (Skovsmose, 2005b). Students' designated identities are similar to self-directive constructions (Malmivuori, 2006) and needs (Hannula, 2006) as described in Chapter Two. Hannula (2006) described a students' needs as relatively stable and there was stability evident in the students' sets of designated identities in Sfard and Prusak's research (2005a, 2005b) because of their cultural basis. In this thesis, a student's needs are part of their relationship with mathematics and therefore part of the context a student's designated identities occur within.

Indeed, the students' relationship with mathematics can be seen as the context within which both actual and designated identities occur. Learning is a form of participation or engagement that enables students to actualise their relationship through participation in the practices of the mathematics classroom. Research needs to collect evidence of students' designated and actual identities and elements of students' relationships with mathematics, and seek the relationship between them over their mathematical learning journey.

### 3.5 Mathematical learning journeys

Mathematical learning is a complex process that takes place when a student participates in practices of the mathematics classroom. A mathematical journey is the accumulation of this process over time. Much of the identity literature has researched the formation of identity, and similarly the affective literature has written about the formation of the student's relationship with mathematics (mathematical core), yet little has been written about how a student's mathematical journey has changed over time.

One exception to this is Hannula's (2002, 2006) longitudinal research (section 2.3), which followed students over three years and described changes in their attitudes and beliefs, as well as various aspects of their needs, goals, evaluations, and motivations. The students were observed in their mathematics classrooms and were interviewed and given small group tasks outside the classroom. Interviews were also conducted with parents and other teachers, such as their primary school teachers. The affective development of the students was explored over time. For example, in the case study of Rita, her attitude towards mathematics was described as changing dramatically within a few months. Initially, she did not like mathematics and questioned its importance as a defensive strategy. A few months later, although her emotions could still be both pleasant and unpleasant, the balance had changed towards Rita having a more positive evaluation of mathematics. This seemed to occur as she understood mathematics more, and seemed to be associated with her becoming more active in class, asking for help more, and persevering when she experienced difficulties. Yet, it was difficult to gauge why this change had occurred (Hannula, 2002).

Other research outside mathematics education has investigated learners' perceptions and approaches to learning change over time. For example, Bloomer and Hodkinson (2000) studied an group of initially 79 students aged 15 years from English secondary schools. Students were interviewed on five occasions over a 3-year period about their past and present experiences of learning and about any aspirations they held. They tracked the *learning careers* of these students, a concept which refers to the development of dispositions to learning over time.

[A learning career] is a career of events, activities and meanings, and the making and remaking of meanings through those activities and events, and it is a career of

relationships and the constant making and remaking of relationships (Bloomer & Hodkinson, 2000, p. 590).

Their findings demonstrate that a longitudinal perspective on learning is important. Although a person's disposition to learning could transform in a short period of time, it had elements of both continuity and transformation. Separating the concept of learning career from a student's personal identity, they found that the personal identity of many young people became significantly transformed between the ages of 15 and 19 and transformations in learning careers were tightly bound up with these. They also found that, although economic, social and cultural differences remain powerful influences upon learning careers, the impact of such factors is not crudely deterministic.

A longitudinal perspective is imperative in mathematics education. Boaler and Greeno (2000) described the figured world of the mathematics classroom as often "narrow and ritualistic, leading able students to reject the discipline at a sensitive stage of their identity development" (p. 171). As was described in Chapter One, adolescence is a time of fluidity when young people explore how they are connected to their social environment and so it is vital to find out how students' relationships with mathematics change over time.

### 3.6 Conclusion

A student's relationship with mathematics (called a mathematical core in Chapter Two) is understood to have both individual and shared components, which are constantly changing as the students participate in the mathematics classroom and in other communities of practice. The meanings students construct from their interpretations of their learning experiences and performances either reinforce or alter its elements. Therefore, students' relationships with mathematics are constantly changing. Nevertheless, there are possible elements of stability within them.

The notion of identity as a narrative has suggestions about how research should be conducted. Following Sfard and Prusak (2005b), in this research, students' *mathematical identities* are viewed as the reifying, endorsable, and significant stories that relate students' to mathematics – specifically relating to their expectations of success and their perceptions of their own ability. These stories occur within the context of mathematics classrooms and are sensitive to the current context the students find themselves within. Identities are a product of the

student's negotiation with the current context and their relationship with mathematics.

Identities are a better indicator of this negotiation than a student's behaviour, as had previously been used in affective research, because they are from the student's and not the researcher or teacher's perspective. How these identities relate to students' affect, the stability of students' relationships with mathematics, and how the identities contribute to students' mathematical learning journey is a critical gap in the literature. Chapter Four details how research into this gap was conducted.

## CHAPTER FOUR: The Research

The purpose of this chapter is to describe how students' mathematical journeys were investigated. In examining students' journeys – their relationships with mathematics over time, students' identities and mathematical affect were explored. Specifically, the following questions were investigated:

1. What is the nature of students' relationships with mathematics?
2. How are these relationships associated with mathematical learning?
3. How do these relationships change over time to form students' mathematical journeys?

These questions developed as my understanding grew about the complex issues surrounding students' journeys through mathematics. To address the concerns expressed in Chapter One, I began with ideas about barriers to learning, in particular the psychological construct of mathematics anxiety, described in section 2.1. Students in the classroom were initially identified who 'suffered' from mathematics anxiety. My focus changed as I began to understand that the affective domain as a whole needed to be considered to capture the complexity of the issue (section 2.2). Furthermore, both positive and negative affective responses needed to be studied across a full range of intensities. As a result of initial investigation of research described in the previous chapters, I recognised that mathematical affect was only one component of the students' relationships with mathematics and the nature of these relationships and how they were associated with mathematics learning needed to be explored. A temporal dimension was incorporated to help capture changes in the students' relationships with mathematics over time to understand how they contribute to students' mathematical learning journey. Furthermore I recognised that the students, as mathematical learners, were participating in a social world both within and beyond the mathematics classroom. Sfard and Prusak's (2005b) conception of identities, detailed in section 3.4 emerged as an important tool because of the way identities linked individuals with this social world.

In this chapter, the methodology that underpins the research is explained and the specific methods are detailed. Ethical considerations, and decisions relating to the participants of the research are described. Issues of quality are also explored.

## 4.1 A qualitative framework

This section explains the framework that was employed to answer the research questions. A metaphor of a passenger train is used to illustrate this explanation. The train represents a student on their journey through school mathematics.

*An overnight train flashes by and I glimpse some of the passengers. There is a young girl reading, absorbed in her book. A man is slumped uncomfortably, dozing in his seat. A group of people are laughing, with drinks in their hands and heads thrown back. Some windows are dark, and I am unable to see inside.*

Just as the train can easily be described (silver, modern with bevelled edges), a student can also be described (tall, thin with blonde hair). To describe what is going on inside that train is more difficult. The train goes quickly past, allowing only a brief look. Each window of the train represents a glimpse of a student's journey – a test result, a comment from the teacher, or an incident observed within the mathematics classroom. These glimpses may not be significant to the student or endorsed by them and therefore may not contribute to the student's relationship with mathematics. Indeed data about a student – a lit window seen from outside the train – does not necessarily convey any tangible essence of their journey. These glimpses are a series of representations (Denzin & Lincoln, 2005) of a subjective and ever-changing reality. Data – glimpses of the student – are seen in this research as opportunities for possible insights and a base for interpretation and further data collection.

To capture students' journeys, non-numerical (Johnson & Christensen, 2004), qualitative research was undertaken. The inductive and interpretive practices (Denzin & Lincoln, 2005) of qualitative research allowed students' journeys to become more visible. Importantly, the research was from the students' perspective. It was the meanings students took from a situation or experience that were important, although of course these are done through my interpretation. Furthermore, to capture the association between students' relationships with mathematics and students' learning, the research took place in the actual mathematics classrooms. This was because, in this research, learning is considered to be a social phenomenon. The students constructed meaning through participation in the practices of the mathematics classroom, and their mathematical journeys are situated in the classroom and in the wider context of the school and their family life. Within their journeys, students' affective

responses and identities happen within the context of the classroom and are not detachable from the specific individual and the current situation (as discussed in sections 2.2 and 3.4).

Ensuring quality in this research process was important so that researchers and practitioners can have confidence in the conduct of this investigation and its results. Researchers talk about the quality of research in different ways, such as validity and reliability (e.g., Cao, Bishop, & Forgasz, 2006; Strauss & Corbin, 1998), or trustworthiness (Lincoln & Guba, 1985). However, there is general agreement that establishing rigour in the quality of research is central.

For an inquiry to be trustworthy (and therefore be of good quality), it needs to have the four criteria of credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). The internal validity or *credibility* of the research refers to “the correctness or credibility of a description, conclusion, explanation, interpretation, or other sort of account” (Strauss & Corbin, 1998, p. 137). Simply put, the reader needs to be able to distinguish “accounts that are credible from those that are not” (Maxwell, 2005, p. 106). As an experienced mathematics teacher in the research school, by carrying out longitudinal research with extensive triangulation, and by having intensive and regular supervision, credibility was assured. In this research credibility was mainly concerned with ensuring data was as close as possible from the students’ perspective and minimising my interpretation. The students sometimes seemed to say the right thing, doing this because of their perception of me as a teacher-researcher or perhaps fulfilling the correct social role, so important to these adolescents. In this research, although the students told different stories at different times, each story was considered to be their interpretation of the world at the moment when they told that story.

Adjusting one’s story to listeners is not a sign of insincerity but rather stems from the need for solidarity and effective communication ... it is the activity of identifying and not the end product that is of interest to the researcher ... narratives that constitute one’s identity, being an important factor in shaping this person’s actions, will be useful in research even if they communicate one’s experience only as well as human words can tell (Sfard & Prusak, 2005b, p. 17).

Furthermore, affecting data in this research was what is termed the *Hawthorne effect*, where subjects under study realise their role as guinea pigs (Cohen & Manion, 1994) and present an ideal self. In other words, my interest in them may have meant they altered their stories to the

ones they thought I wanted to hear (Burns, 1990). The breadth of the research design (section 4.1.1) helped to counter this.

*Transferability*, or external validity, is the extent to which the results of the research can be generalised or transferred to other contexts. The results of this research have not been generalised to other populations. However, to help the reader make their own judgements about the transferability of the research, rich, detailed descriptions of the context, methodology and results were provided so that the reader can judge the applicability of the findings to other settings.

*Dependability*, or reliability, refers to the extent to which research can be replicated (Merriam, 1998). Reliability in qualitative research is sometimes discounted as irrelevant or misleading (Golafshani, 2003). Indeed, this research cannot be truly replicated because it involved humans and other researchers may interpret the data differently because of their different theoretical positions. However, it is important to persuade the reader that the research findings are worth paying attention to (Lincoln & Guba, 1985). Important to reliability was the detailed documentation of all stages of the research process. For example, in this chapter, there are details of the inclusion of possible bias and assumptions, rich, detailed descriptions of the mathematical and sociocultural context and the detailing of decisions made during data collection and analysis.

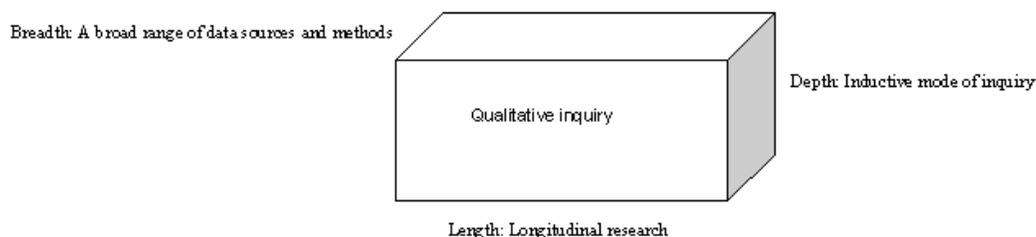
*Confirmability* is a measure of how well the inquiry's findings are supported by the data collected. Similarly to dependability, confirmability was achieved through provision of a documented trail of raw data and the steps of the analysis process. This trail included constant reflection in the form of the third column analysis (section 4.5.1) and consistent checking of interpretation by the supervision team.

### **4.1.2 Length of the research**

The students' mathematical journeys were researched over two years from when they were aged around 14 years until when they were aged about 16. If this research had been conducted during one day in the student's lives or even over one term, data collected may not be significant to the students' overall journey through mathematics. Students have a variety of mathematical experiences which lead to the development of their affective views (Schuck & Grootenboer, 2004) and which affect their relationship with mathematics. Although it is acknowledged that a person's journey through mathematics lasts longer than a two-year

period, this research is concerned with adolescents' mathematical journeys. The research period of two years allowed students' perceptions of mathematics to be explored through changes of teachers, classmates, physical locations, expectations, and curriculum in the years leading up to mathematics being no longer being compulsory. The two years allowed changes in students' more stable overall feelings about mathematics to be captured and more generally, allowed changes in their relationships with mathematics to be investigated. The two years allowed many glimpses of the students' journeys to be collected. Furthermore, by having intensive, longer-term involvement with the students, they got used to my presence in the classroom, reducing the effect of researcher involvement.

In this research, students' mathematical journeys were explored by using interview data, questionnaires and other data to capture their identities, stories of their relationship with mathematics, and their interpretations of their experiences and the context of the mathematics classroom. To enable me to best gain access to students' journeys through the glimpses I received, three inter-related dimensions of breadth, length, and depth were required.



**FIGURE 4.1 Breadth, length, and depth of the research methodology**

### 4.1.1 Breadth of the research

The breadth of the research refers to the multitude of tools that were used to collect data. As “no single method can grasp all the subtle variations in ongoing human experience” (Denzin & Lincoln, 2005, p. 21), breadth of research was needed to ensure data was from the students' perspective, to make their journeys visible in different ways, to confirm the emerging findings, and to make decisions about the research process.

Boaler's (2002b) research reinforced the importance of using multiple research tools to answer questions about mathematics classrooms as socially constituted entities. Boaler (2002b), who also viewed learning as a social practice, conducted research which centred on students' identity and some aspects of affect. She explored the mathematical experiences of

groups of students (aged 13 to 16) and their teachers in two English schools over three years. She spent time in the schools and the mathematics classrooms, performing extensive observations, interviewing teachers and students, and conducting assessment tasks.

The multitude of methods used ... enabled me to develop an understanding of the students' experiences and begin to view the worlds of school mathematics from the students' perspectives (Boaler, 2002b, p. 7).

By using such a range of methods, she explored multiple aspects of schools' cultures and the students' mathematics learning, and was able to provide rich descriptions of the lived experiences of the students during instruction, and portraits of students' knowledge, beliefs and mathematical identities. Boaler's (2002b) research provided guidelines for ensuring students' relationships with mathematics were captured from their perspective in the current research.

Students' identities, as defined by Sfard and Prusak (2005b) and detailed in section 3.4, were sought through the stories that the students told. A person has a number of stories told about them by different narrators, including themselves. Students' self-dialogue (thinking) includes powerful identities but, due to its nature, was unavailable for research. Identities include a person's spoken-out-loud stories about themselves, and stories detailed in their written responses. Identities, according to Sfard and Prusak (2005a, 2005b) also include extra-discursive stories. These other data sources were used to gain background to students' identities and to help guide research decisions. Sfard and Prusak (2005b) included institutional narratives in their research, such as examination results, implying that reifying stories from other sources may contribute to students' sets of actual identities. Stories from other sources that had potential to become part of students' sets of identities were therefore sought to help build a clearer picture of each student's mathematical journey. These stories include:

1. Stories from other narrators
  - Teachers
  - Classmates
  - Parents and Siblings
2. Extra-discursive stories
  - Class placement
  - Class positioning

- Assessment results
- Prizes and awards

Importantly, these stories were seen only as potential data. They were not from the students' perspective, and further data collection was needed to ensure they were significant to the student and endorsed by them. It was never assumed that an event in their journey, such as receiving a prize, was significant to the student. A teacher's view of a student's ability may have been simply a reflection of the teacher's beliefs about how they perceived the student should behave in the mathematics classroom. The teachers and parents were not, therefore, considered to be participants in this research.

It is acknowledged in this research that using Sfard and Prusak's (2005a, 2005b) view of identities means that it is difficult to ascertain students unconscious and preconscious processes described in section 2.3. However collecting students' identities as well as their affective responses using, for example, Evan, Morgan and Tastsaroni's (2006) discursive approach to emotions counters this somewhat. By studying students emotions and listening to them talk about their feelings, some of the unconscious selves of the students are able to come to the surface through the students' emotions, even if somewhat indirectly.

A broad range of tools was used because of the need to capture affective data within students' mathematical journeys. Researchers working in the affective domain deem a broad range of methodologies and methods to be necessary both across and within research projects to capture the complexity of affective issues (Leder & Grootenboer, 2005a; Zan et al., 2006). Indeed, DeBellis and Goldin (2006) suggested the use of many 'windows' of distinct information sources to allow students' mathematical affect to be better captured. Using one method of collecting affective data, such as observations, is risky. There may be differences between students' espoused and enacted views of mathematics (Beswick, 2005a). In other words, if a student described a particular view of mathematics, this may not translate into how they behave in class or be evident from that behaviour. Furthermore, the nature of the research surrounding the affective domain is, for the participants, of a highly personal nature. Students' emotions and feelings are often difficult to verbalise, and this leads to difficulty in both collecting and interpreting the research data (DeBellis & Goldin, 2006). Emotions, in particular, are difficult to capture in research because of their transitory and unstable nature (Op 't Eynde et al., 2001). Hannula (2006) noted that students' emotions and feelings can only be observed when they are of sufficient intensity and described by the student when they are

conscious of them. There is too the “problematic process of tempting people into revealing” them (Hannula, 2002, p. 17). Some researchers (e.g., Kloosterman, 2002) indicate that the nature of mathematics as a discipline is not an issue that secondary school students think about and thus have difficulty in defining.

*Triangulation* is a process of using multiple perceptions to clarify meaning, and to confirm the emerging findings (Merriam, 1998). Having a broad range of methods and sources allowed triangulation to occur. It enabled me to understand or accept contradictions in the narratives that the students told. There were sometimes disparate, incompatible, even apparently contradictory information (Merriam, 1998) in data. Data often came from different narrators and was addressed to different audiences. Commonly, for example, a student response to the question about how mathematics was going for them was ‘OK’, whereas other data seemed to contradict this perspective. Stories sometimes seemed contradictory because they were individual visions of people’s experiences, interpretations of other stories, and were moulded depending on the recipient of the story.

### **4.1.3 Depth of the research**

Depth was gained through the richness of the analysis that an inductive mode of qualitative inquiry allows (Merriam, 1998). Informed by the qualitative approach, the research was inductive because of the constant movement between data collection and analysis. I used data as an opportunity to learn more about each student, the class, and the context. New data confirmed other data, provided potential contradictions or alternatives, or helped me decide what to collect next and from whom. Decision-making therefore permeated the process of data collection and analysis. As in Boaler’s (2002b) research, described in 4.1.1, all of the research methods were used to inform each other in a continual process of interaction and reanalysis, and the research methods were adapted to the context and circumstances. Data could be used potentially to validate responses through checking directly with the students, as a catalyst for collecting further data, as an example of negative cases, or as an alternative to previous data.

Within the qualitative methodology, I used a *grounded theory* approach, which refers to theory “derived from data systematically gathered and analysed through the research process” (Strauss & Corbin, 1998, p. 12). In this approach, theory is seen as a “set of well-developed concepts related through statements of relationships, which together constitute an integrated framework that can be used to explain or predict phenomena” (Strauss & Corbin, 1998, p. 15).

I used the grounded theory procedures of analysis such as the constant comparison method, multiple stages of data collection and the seeking, refinement and interrelationship of explanatory categories in my research. Inconsistent with grounded theory, however, I analysed the data set keeping in mind specific aspects of affect and identities, further described in section 4.4.2. Furthermore, from the literature in Chapter Two emerged a list of potential components of a student's relationship with mathematics, seen in section 2.3. These elements were not investigated specifically when investigating the students' mathematical journeys. Rather they were kept in mind when analysing data. The three stages of inductive analysis are described in detail in section 4.5.

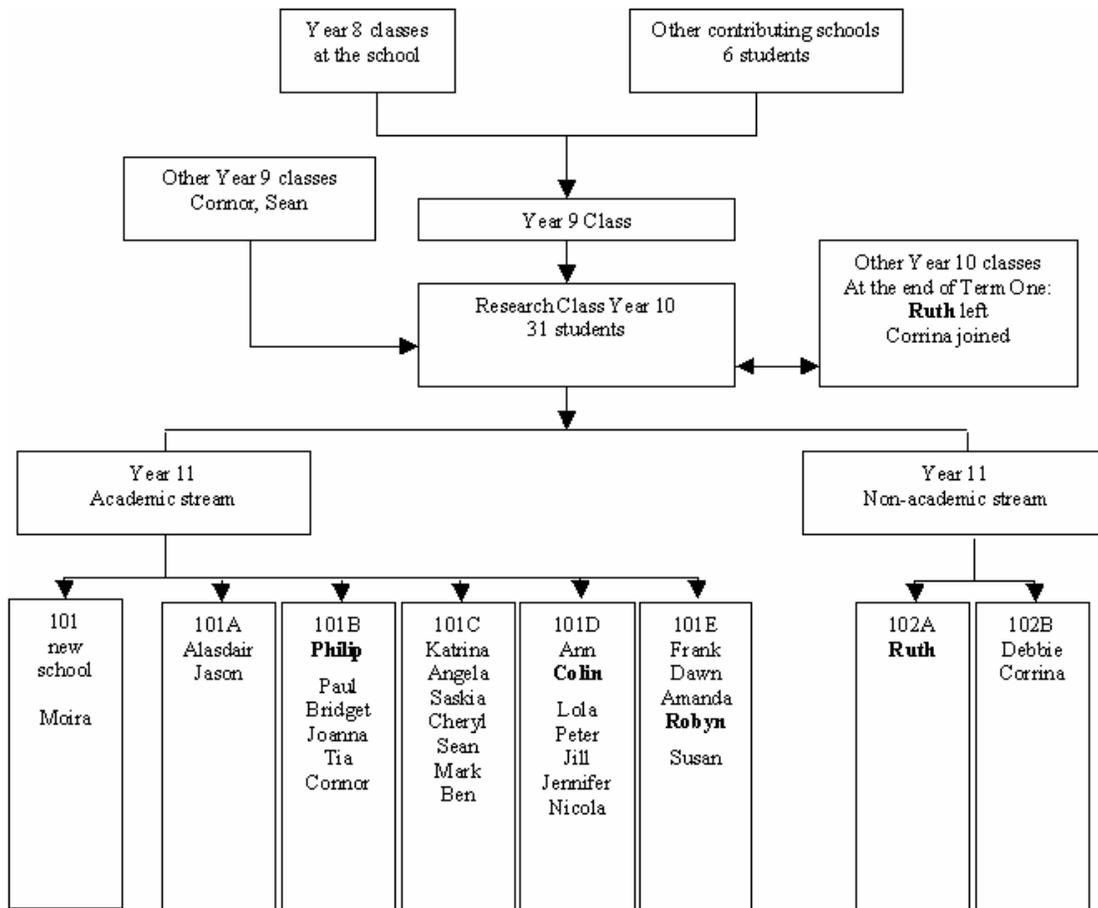
## 4.2 Participants

The 31 participants of this research attended a co-educational school in New Zealand. This school was chosen because it was physically accessible and because I had worked there previously as a mathematics teacher. I therefore had good access to the school and an understanding of the school's culture, the sociocultural backgrounds of the students, the teaching staff, and the disciplinary, guidance, and academic systems.

The school, at the time of research, was a combined intermediate and secondary school, catering for 950 Year 7-13 students (10 to 18 years). Located on the edge of a city, the school looked out on a farm, and had its own theatre, dance studio, and extensive sports fields. The school's mission statement included a commitment to innovation and the promotion of excellence in teaching and learning. Emphasis was placed on offering a broad base of learning opportunities conducted in a safe learning environment. There was a zero tolerance policy at the school for bullying and violence and a number of well-monitored systems in place to support the teachers with classroom management. Class sizes ranged between 20 and 30 students. The students were from both urban and rural areas and the school was decile 5 on a rating scale between 1 and 10. The *decile* indicates the extent to which the school draws its students from low socio-economic communities on the basis of household income, occupation, household crowding, educational qualifications of the parents, and the percentage of parents on income support (Ministry of Education, 2010a). The majority of students at the school therefore came from households of average income where at least one parent worked. Most students at the school were of New Zealand European ethnic origin.

The research began when the 31 students were together in a Year 10 mathematics class, aged 14-15 years. Students within one mathematics class were chosen so that the social norms and views of the class as a whole could be understood as well as the affect and identities of the individual students. All of the students identified themselves as New Zealand European. The make-up of the class was slightly unusual because there were only nine boys. Most of the research students were part of the same class from the beginning of Year 9 and therefore had already been together for a year. The research class was one of six classes at that level and known as the 'achievement class'. This was the label given by the school to the high achievement class. This class placement decision was made when the students were in Year 8 and based on the students' written English and recommendations from teachers. Students were placed in classes in Year 9 with the intention they remain together for two years for the core subjects of English, Mathematics, Science, Social Studies, and Physical Education. Six of the students in the research class came from other schools at the beginning of Year 9. At the beginning of Year 10, two students moved into the class from other Year 9 classes at the school. At the end of term two in Year 10, one student, Ruth, was removed from the class because of a perceived lack of effort and ability. Another student, Corrina, took her place and became part of the research class. Ruth continued to be part of the research and is the subject of a case study in section 7.4.

The research continued when the students were in different Year 11 mathematics classes. The students took three compulsory subjects in Year 11 at different levels (English, Mathematics, Science) and chose three other subjects from a choice of twenty. The students were split into eight different mathematics classes according to timetabling and mathematics class placement. The level of a student's achievement in assessments and the mathematics teacher's judgement were the main contributor to the school's class placement decision when the students were in Year 11. The students were placed in MAT101, which had a combination of externally and internally assessed achievement standards, or placed in MAT102, which only offered internally assessed standards and was designed for students who were perceived as having lower mathematics ability. In Year 11, one of the students, Moira, left the school to attend boarding school in the next town. She continued to be part of the study at this school by being observed and interviewed. Moira also wrote a variety of written responses and kept in email contact with me throughout her Year 11. Figure 4.2 below maps the formation and changes in the class prior to and during the research period, when the students were in Year 10 and 11. Those students who are highlighted in Figure 4.2 are those students who are subject to case studies, described further in Chapter Seven.



**FIGURE 4.2 Class composition in Years 9, 10 and 11.**

In terms of the achievement level of the class, at the beginning of Year 10, the students completed a Progressive Achievement Test of Mathematics (PAT). This was developed for New Zealand schools (New Zealand Council for Educational Research, 2010), and is designed to be given near the beginning of the year to assist classroom teachers to make “informed decisions about the kinds of teaching, materials, methods, and programmes most suitable for their students” (Reid, 1993, p. 3). This test consisted of 50 multiple choice questions arranged in order of difficulty and designed to cover a range of curriculum topics and skills. Raw results from the tests are scaled using national class percentile rank norms. A student with a percentile of 75%, for example, indicates that 75% of the students in the same age nationally had lower scores. At the beginning of Year 10, the research students completed this assessment. Percentile ranks describe a student’s relative position within a particular reference group. The results for the Year 10 research class indicated that, according to this single assessment, all of the students were in the top half of the results for students of their

age in the country. These results were consistent with their Year 9 results. These test scores, when referred to Chapter Seven, are used with the understanding that a single assessment can only examine a fraction of a student's understanding and multiple-choice questions can only test a very restricted type of mathematics. Furthermore the students' scores are affected by the situation the test is taken in for the individual student.

### **4.3 Ethical considerations**

There are moral issues implicit in the work of researchers in terms of their obligations to those involved in, or affected by, their investigations (Cohen & Manion, 1994). It was important to conduct this research ethically to ensure that these obligations were met, especially because the participants were not adults. Therefore, there were a number of strategies in place throughout the research with regard to consent, access, and privacy.

- Ethics approvals were sought and granted from the university's ethics committee. Permission was granted from the management of the school, the mathematics department, and from the teachers concerned. Throughout the research, these groups of people were fully informed of my intentions, requirements, and progress in terms of data collection.
- The written permission of the parents for their children to participate in the research was sought prior to meeting the students. The parents were first informed of the purpose of the research, how it would be conducted, how they would be involved, and they were given the opportunity to ask questions.
- All the students who took part in the study were informed what the aims of the research were. Each was given an information sheet and a consent form, which they all completed. They were informed of their right to withdraw at any time and were informed that if I gained knowledge of potential harm, I may need to disclose information to the school guidance counsellor.
- The students' identities were protected so that the information collected would not run the risk of embarrassing them or harming them in any way. Confidentiality was maintained at all times and this anonymity was extended to the verbal reporting of information. All participants, the teachers, and the school, were identified by pseudonyms in all research reports and in this thesis.

## 4.4 Methods of data collection

To answer the research questions, and to ensure breadth, length, and depth, over two years, the students were observed in their mathematics class, they were interviewed, and they were asked to submit a variety of written responses. Many school documents were also collected (see Table 4.1 below). Some of these documents were from prior to the research period and were therefore collected retrospectively.

NVivo (QSR International, 2006), a qualitative data analysis software package, was used to enable the large data set to be managed and to aid analysis. Data, whether it was an interview transcript, a field note, or a school document was entered into NVivo or linked with NVivo in its entirety so detail was not lost. Having the research data entered into one software package ensured the security and longevity of the original research documents and meant data was accessible for analysis.

How the research tools in Table 4.1 were used to answer the research questions is described in detail below. It should be noted that, although teachers and parents were not considered participants in this research (section 4.2 above), they were asked to contribute to the research process in order to get a better understanding of the students' relationship with mathematics. Parents were asked to complete a questionnaire (see Appendix D), and the teachers were asked for written feedback on each of the students in terms of students' achievement, progress, and engagement in the mathematics. The Year 9 and 10 teachers were also interviewed about the class as a whole and each individual student. These interviews were audio taped, transcribed and inductively analysed in a similar way to the student interviews (section 4.4.2 below).

**TABLE 4.1 Research tools used**

Research tools		Pre-Year 10	Year 10	Year 11
Observations	Mathematics classes		√	√
	English classes			√
Student interviews	Individual		√	√
	Group		√	√
Students' written responses	Metaphors for mathematics		√	
	Drawings of mathematicians		√	
	Personal journey graphs			√
	Questionnaires		√	√

	Exercise books		√	
School documents	Enrolment information	√		
	Mathematics class attendance		√	√
	Assessment results	√	√	√
	Reports	√	√	√
	Prizes	√	√	√
	Subject choices		√	√
Teacher	Teacher feedback		√	√
	Interviews	√	√	
	Metaphors for mathematics		√	
	Teacher drawing of mathematician		√	
Parent questionnaire		√		

#### 4.4.1 Observations

Observing mathematics lessons allowed me to collect glimpses of the students at different moments in their mathematical journeys. Through observations, I was able to enter the students' physical world and also begin to understand their social world. I began to get to know the students as a class and as individuals, understand the social norms of the classroom, hear the language students used to talk about mathematics, and see the teacher and student interactions. I was able to observe the students engage in mathematics lessons and make note of their behaviour, the strategies they used, their affective responses, and collect evidence of the work they produced. These glimpses allowed me to begin to build a picture of the students' social and individual relationships with mathematics. Observing students over a two-year period alerted me to potential changes in their relationships with mathematics.

It quickly became apparent that I could not observe the complex behaviours and interactions of thirty-one students in detail during one observation. I chose three or four individuals to concentrate on for each lesson either because I was drawn to them by naturally occurring events, to substantiate findings from other data sources, or because I had not observed those students already.

As an experienced teacher, I was already a practised observer of students in a classroom. However as a researcher my intentions and focus were different. Although the class was informed about my intentions, and the group understood my role as an observer, I was introduced as, and recognised by some, as an ex-teacher at the school. When walking around the classroom, students often invited me to participate by asking me mathematics questions

and therefore, with permission of the teachers, I became a participant-observer in this research. I was on the continuum between participant and observer (Merriam, 1998), although very close to the observer role. I often experienced a tension between participating naturally and a feeling that I needed to observe from the back of the classroom to capture detailed observations. I rarely approached a student to see if they needed help unless someone was obviously stuck, the teacher was busy, and they were displaying strong indicators of negative affect.

*Ethnographic* research is concerned with the sociocultural features of the mathematics classroom, where culture can be viewed as the beliefs, attitudes and values of a group of people (Merriam, 1998). This research is ethnographic in the sense that the social norms and culture of the classroom were explored. This was to allow understanding of the association between students' relationships with mathematics and the social norms of the mathematics classroom. Furthermore, by school mathematics being described, the reader can better understand the context of this research and "decide for themselves about the relevance of the reported experiences to their own settings" (Boaler, 2002b, p. 186). Rather than describing these practices myself, however, school mathematics was described from the students' perspective.

What matters is not the classroom environment and practices as observed by the researcher, but the meaning students ... give to situations and how they are constituted through interactions in class. In their actions, they renegotiate the meanings that are prevailing, continuously creating new situations to which they relate in different ways (Op 't Eynde et al., 2001, p. 159).

My observations were not from the students' perspective but my own, and filtered through the lenses of my own subjectivity, language, and sociocultural background (Denzin & Lincoln, 2005). My description of the atmosphere of a class, for example, is subjective. Observations were not therefore sufficient evidence by themselves of students' relationships with mathematics.

We cannot observe feelings, thoughts, and intentions. We cannot observe behaviours that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organised

the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things (Patton, 2002, p. 341).

As in Mendick's (2006) research, the observations were not regarded as the truth. Instead I hoped they were the catalyst for more complex analyses of the students' relationships with mathematics. Any observation therefore needed to be endorsed by the student and confirmed by other research tools. Mainly, the observations were a catalyst for decisions about what to ask the students in interviews and in written feedback. During one observation, for example, a boy sat with his face down on the desk after a particularly difficult problem and muttered, "I can't do this". I had written a field-note that perhaps he was having trouble with the problem he was working on, and had become frustrated and upset. I chose to interview him the following day and ask him about what had happened. What I had observed was not an affective response to the mathematics context. Rather he had broken up with his girlfriend the hour before and was not even following the lesson. He did experience affect, but it was not attributable to mathematics.

General comments about the physical environment of the class were written to get a better understanding of the context the students worked in. In general, the classrooms were large, well-heated, carpeted spaces with big windows and a whiteboard at the front of the room. In each of the rooms were about 32 student desks and chairs, a larger desk for the teacher, and a shelf of textbooks at the back of the room. There were no computers or data projectors in the mathematics classrooms.

Observing and making note of the social environment and social and socio-mathematical norms of the class was important to better understand the context of the students' mathematics classrooms. Observations were made of the social groupings in the class, the atmosphere, the general engagement and behaviour of the students, any use of specific language and cultural norms, interactions between students and teachers, and interruptions to the class. I also noted teaching style, the use of textbooks and the white-board, the classroom routines, and the use of mathematical strategies when students experienced difficulties. Any deviations from these norms were noted. The patterns of individual student interactions were noted in detail. I noted instances in the classroom when students were seeking and asking for help to understand what the norms were in the class and how these formed part of students' relationship with mathematics. I looked to see how students asked for help, if students gave or received help from others, how they asked for help and whom they asked. I also noted which students

volunteered answers to questions posed by the teacher, and sought to understand the norms of interaction when students sought help from the teacher. Notes were also taken about both how the class as whole, and individual students entered and exited the classrooms. Did they come in with other people? Did they greet me, the teacher and other members of class? What were their facial expressions? What was their behaviour before the lesson? Did they get any equipment out before the start of the lesson? Did they do any mathematics or discuss any mathematics before the start of the lesson? Did they remain behind to ask the teacher any questions? Did they leave the classroom talking about maths or their feelings about it? What was their behaviour as they left the class?

During observations, to understand how affect formed part of students' relationship with mathematics, I looked for indications that the students were experiencing affect in the classroom, using these observations to follow up in interviews and with other research tools. Introduced in section 2.3, Evans et al.'s (2006) textual analysis of transcripts influenced the indicators of affect sought in this research. These indicators developed further during the research process.

- Verbal expressions of feelings, such as boredom, worry, frustration, enjoyment
- The use of metaphors, e.g., Philip is cruising
- Emphasis given to words through, for example, repetition and intonation
- Denial, jokes, justifications, including the use of the collective, for example "we had trouble"
- Negative or positive self-talk
- Body language, facial expressions, gestures, blushing, hair pulling, eye tics
- Behaviour different to the social norms of the classroom, excessive social chat
- Excessive cautiousness, extremely neat work, reduced responsiveness to the environment
- Avoidance of mathematics such as going to the toilet, social chat, organising equipment, ruling up pages of exercise book excessively
- Resistance to authority figures, including teachers and students in the top group
- The level of dependence on help from the teacher or peers.

Students' engagement in the mathematics emerged as an important link between their relationship with mathematics and their learning (section 5.1). Caution was used, however, to observe students' engagement in the mathematics. A student's behaviour did not necessarily

indicate that they were engaged in the mathematics. If one student was observed to have their head down and be working steadily, and another to be chatting socially while they complete their work, it was possible that both of the students were engaged in the mathematics. I noted in one observation, for example, that Mark was very engaged in the mathematics. When I asked him about this high level of engagement in an interview the following day he laughed and showed me in his book the seventeen games of Connect 5 – similar to noughts and crosses – he had played that day. Observing a student’s classroom behaviour as an indicator of learning may only indicate that the student is aware of and keeps within the social norms of the class. As Yair (2000, p. 249) noted, it cannot be “implicitly assumed that a calm physical presence could be equated with cognitive presence” (p. 249). It is more tenable to describe the students’ engagement from their perspective using other research tools.

When the students were in Year 10, I visited their fifty-minute mathematics class 32 times over a nine-month period. When the students were in Year 11, and no longer in the same mathematics class, I observed each of their eight mathematics classes twice and each of their eight English classes once, a total of 24 further observations. Field notes were written during the class as notes on blank sheets of paper. I did not record my observations in any systematic way during this time; rather I responded to what was happening in the class, while keeping in mind the goals of my research. These ethnographic-style (Eisenhart, 1988) field notes were then transferred onto an observation template on the same day, which can be seen in Appendix A.

I videoed the lessons to capture better the students’ interactions, positioning the camera variously around the room to get broad sections of the class. Although I had explained to the students that the camera was not focussed on any individual but rather on the class as a whole, it took some time for the students to settle with the video camera. After two weeks, a boy switched off the camera without my consent, forgetting that he was videoed as he walked towards the video camera to do so! The humour this incident generated and the ensuing discussion created a natural end to the settling-in period and there were no further incidents and little reference made to the camera. In the students’ Year 11, no videoing was done because the consenting participants were only a small proportion of each class. .

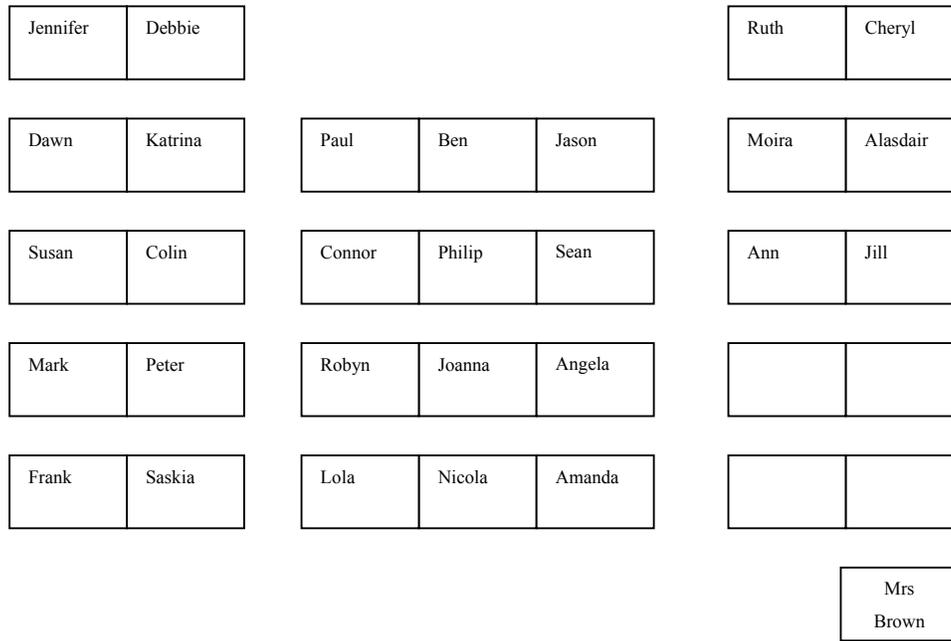
As with other research tools, the observational template included a third column for initial interpretations (described in section 4.5.1). I viewed the videotape on the day that filming had

occurred and used this to enrich the observational field notes. An example of an observation field note that has been enriched after watching the video is seen below.

From the Physical Education changing sheds and into the empty classroom the boys come, flinging open the door, running, pushing, jostling, shirts untucked, fighting over the desks, laughing, swearing, and arguing about the volleyball game. The girls follow in groups of three or four, texting on their phones, negotiating where to sit, plaiting their hair, and getting out food to quickly eat or position for illicit eating. A couple of people go to the cupboard and start flinging textbooks at people – one between two. Some students complete their homework or copy others'. A few get out exercise books, which then lie unopened on the desk. Some students sit quietly. Most continue with their social dance and wait for the teacher to lead them into the maths lesson.

In addition to general comments about the class, each student had a field on the template and observations about that student were written in. Writing comments about each child individually and providing a space for every student on the research template made a visual record of which students had been observed that day and which students had not. Documents that related specifically to observed classes were collected throughout the study. These included, for example, a copy of the worksheet the students were doing, a copy of the assessment, or a photocopy of the pages in their exercise books on which they wrote the answers to textbook exercises.

For each observation, a seating plan was drawn. This was done in response to initial analysis that seemed to indicate that who a student sat near seemed to make a difference to how they felt about doing the mathematics. There was a range of desk arrangements throughout the research period. Desks were sometimes grouped together with the students facing each other, or, depending on the previous lesson, in test formation. Mostly, the desks were arranged in rows of twos, or pushed together in fours facing the whiteboard. When the desks were arranged in pairs, as in Figure 4.3, below, or in rows of fours, roughly one third of the students sat adjacent to a wall and many of them leant against it, changing their orientation 90° and allowing them better 'access' to students in front and behind them. When the students were in Year 11, where the researched students sat in relation to other students, the teacher, and where they sat in the physical classroom was noted.



**FIGURE 4.3 An example of a seating plan**

Dressing similarly to a teacher, I sat at the very back of the classroom making sure I was already seated when the students came into the classroom. I ensured I had eye contact with each of the students as they came in, and greeted them if they acknowledged me. Any note-taking was done at the back of the class so students did not see what had already been written down and were not overly conscious that notes were being made. I remained seated for most of the lesson keeping still if the teacher was talking to the class as a whole, but for some part of each lesson, I walked around the classroom. This allowed me to see the students unable to be observed from the static point at the back of the classroom, and it allowed me to see the progress of students' work, see their facial expressions more clearly, and engage with them.

My participation became more frequent during the students' Year 10 as the students became more comfortable with me. This participation has implications for the research because students who accepted me as a teacher may have regulated their behaviour in reaction to this and although it had the potential to enrich data, it also had the potential to overtake my primary role of observer and writer of field notes. I found I was able to disengage by sitting down at the back of the classroom again. The students too became accepting that often I was not available to help them but was in my role of an observer. I also tried to combat an entrenched teacher role by introducing myself to the students using my first name.

When the students were in Year 11, participation was more difficult because other students who were not research participants were present. On four occasions I was not introduced by the teacher to the class and therefore did not feel able to walk around the classroom during the lesson or engage with the students. The field notes from these lessons are, as a consequence, not as rich as those where I was able to walk around. English classes were observed in Year 11 to gain depth to data collected from students who compared mathematics to other subjects in their interviews. Students often discussed mathematics in comparison to English. Furthermore, I was very familiar with mathematics classrooms because of my teaching background and needed to counter potential issues with taking the routines for granted. Observing the English classes enabled me to notice more about what was particular in the mathematics classroom. Exploring the difference between mathematics and English was a research tool but not reported on specifically.

#### **4.4.2 Interviews**

The interviews were important because they allowed me to directly access the students' perspective on their dynamic relationship with mathematics, and how they associated this relationship with mathematical learning. Also, in the interviews, the students reflected on experiences and aspects of their mathematical journey. The interviews allowed me to capture the individual complexities and even contradictions of their individual perceptions and experiences. I was also able to follow up on potential affective responses observed in class, collect further evidence of affect (section 4.4.1) and to clarify other data. Through the interviews, I collected data about the students' views of mathematics and mathematical learning and clarified the social and socio-mathematical norms of mathematics I had observed in the classroom. Further differentiating this research from beliefs research (section 3.3 for further discussion), the students' views reported here are described by the students rather than inferred from students' behaviour or collected through quantitatively analysed questionnaires. Through the interviews, especially, I was able to learn the language the students used to describe mathematics. Indeed, the students had a unique register when discussing mathematics. I was not familiar with the word 'gurning', for example, which was one of the terms used to describe disengagement in the mathematics (section 5.1).

The interviews were the main tool for the collection of students' identity narratives, which form an important part of students' relationships with mathematics. Interviews are not about simply "the giving and receiving of information but at least as much about speaking identities into being, solidifying them and constantly reconstituting them through the stories we tell

ourselves and each other” (Epstein & Johnson, 1998, p. 105). Sfard and Prusak’s (2005a, 2005b) concept of identities as significant, reifying and endorsable stories about a person (described further in section 3.4), were sought in the interview data. They were distinguished as actual and designated using the criteria set out in Table 4.2 below. This table is adapted from Sfard and Prusak (2005a, 2005b), and uses examples from the current research.

**TABLE 4.2** Categorising identities

Type of identity	Definition	What to look for	Examples from data
<b>Actual identities</b>	Assertions or objectifications about a person about what is actually happening at the time	<ul style="list-style-type: none"> <li>• I am</li> <li>• She/he is</li> <li>• May be context dependent</li> <li>• Present tense</li> <li>• Always, never, usually</li> </ul>	<ul style="list-style-type: none"> <li>• Mark is a poor mathematician</li> <li>• I am no good at algebra</li> <li>• End of year mathematics exam result: Excellence</li> <li>• I am always getting stuck.</li> </ul>
<b>Designated identities</b>	A state of affairs expected to be the case now or in the future	<ul style="list-style-type: none"> <li>• May be less context dependent than actual identities</li> <li>• Future tense</li> <li>• Words that express wish, commitment, obligation or necessity: should, ought, have to, must, want, can/cannot</li> </ul>	<ul style="list-style-type: none"> <li>• I should be doing better at maths.</li> <li>• Everyone else in the class is fine. I should find [maths] easier.</li> <li>• I need to try harder and work more.</li> </ul>

Each student was interviewed once in Year 10, either singly or in a pair if they felt more comfortable. 4 of the 31 students in Year 10 chose to be interviewed in pairs rather than individually. In Year 11, students were interviewed in small groups, with the exception of Saskia, who was interviewed on her own because of previous absences. During the interview period, I attended the mathematics lesson and observed the lesson in the usual manner. During this lesson, the interview time was negotiated with the teacher. These times were fluid so that the students did not miss new material being taught in class, other subjects, or break times. The interviews were conducted in an adjacent office to the classroom. Attempts were made to make the students feel as comfortable as possible. The interview time was restricted to around half an hour, which was inadequate for some of the interviews. Those interviews needing longer were extended on the granting of both the student and teacher’s consent.

The interviews in this research were conversations with a purpose (Maykut & Morehouse, 1994). In other words they were semi-structured with open-ended questions. The questions below initially guided the interview. Some students covered these topics without prompting and their interviews were conversations about mathematics.

- What are your earliest memories of maths?
- How do the people in your family feel about maths?
- What do the people in your family think about your maths?
- Tell me about the best maths experience you ever had.
- Tell me about the worst maths experience you ever had.
- When you think about doing maths, what do you feel?
- How do you behave in maths compared to other classes?
- How do you feel when you come across maths in other subjects and daily life?

Other questions developed throughout the data collection as understanding grew of the issues involved and in response to other interviews, observations made about the individuals in class, or to their written responses. Some examples of these questions are below.

- Tell me about that Algebra starter we had last week.
- When you come across a maths problem you think is hard, what happens?
- How does who you sit next to affect how you do the maths /feel about maths?
- Do you feel competitive with others in the class?

Each interview was audio-recorded, transcribed by myself, and entered into NVivo. I listened to each interview at least three times during and after the process of transcription. This enabled me to become very familiar with it whilst continuing with the data collection. I asked the students to clarify parts of the transcription on a number of occasions. Furthermore, many of the students were asked further questions after their interview either by me directly asking the question in class or by me writing down the question on a piece of paper and getting them to respond in writing, identifying this as a further response.

The record of the interview included the transcription, the time and date of the interview, and general observations made about the student's behaviour in the interview. Initial interpretations were noted in a third column (section 4.5.1) and these were added to throughout the research process.

At all times I was aware that students' discomfort with the research process or their awareness of my role may affect the interview (discussed further in section 4.1.1). One student in Year 11 described his interview the previous year as being very helpful in clarifying his thoughts and goals. He said it had affected his engagement in mathematics. Perhaps he was telling me what he thought I wanted to hear, or perhaps the interview was an intervention which affected him (Patton, 2002).

### 4.4.3 Questionnaires

Questionnaires collected further student perceptions of their relationships with school mathematics. The interviews were restricted because of time and, possibly, students' reluctance to talk to me directly. These questionnaires were another way of accessing that information. The students were given two types of questionnaires to fill out during the research process, as seen below in Table 4.3.

**TABLE 4.3 Questionnaires used in the research**

Questionnaires	Year 10	Year 11
Mathematics autobiography	√	√
End of year questionnaire	√	

Students at the beginning of Year 10 were asked to fill in a mathematics autobiography and this was repeated in Year 11. Kaasila, Hannula, Laine and Pehkonen's (2007) use of autobiography was helpful in constructing these questionnaires. They researched pre-service teachers' own views about themselves as learners of mathematics and investigated how these changed during their teacher education course. They identified data that appeared to be significant to the participants' view of mathematics and mathematical identity. This analysis resulted in a mathematical biography, which revealed how the person had constructed their mathematical past, present and future. They captured students' stories about their previous mathematics experiences using autobiographical narrative, interviews, and the Fennema-Sherman self-confidence scale (further described in section 2.1). They defined a *narrative* as a "story that tells a sequence of events that are significant for the narrator and his or her audience" (Kaasila et al., 2007, p. 112).

The autobiography designed for this research (see Appendix B) had two parts. The first part consisted of a group of closed and open-ended questions. Many of the questions were similar

to the interview questions, but in a written form. It aimed to find out about students' views of school mathematics by asking whether they would take the subject if they had a choice. It also asked the students to compare their perceptions of their achievement and worry about mathematics with their other subjects. Then students were asked about their preferred learning styles, their level of general understanding in class, and the help they received outside of class. The second part of the autobiography consisted of a Likert-type questionnaire on feelings in mathematics. Questions were adapted from a mathematics anxiety scale for children, designed by Chiu and Henry (1990) and from a mathematics attitude survey by Fennema and Sherman (1976). Students responded by first selecting a response on the scale 'not nervous' to 'very nervous' and then by ticking a response on the scale between 'strongly disagree' to 'strongly agree'. The questions were adapted to the New Zealand context. Two examples of changes made were that the word 'math' was replaced with 'maths', and the money example was changed because one and two cents are no longer legal tender in New Zealand.

This autobiographical tool was used in conjunction with the other research tools described in section 4.4. The results were not quantitatively analysed. Instead, as with other research tools, data was interwoven with the different data sources and used to confirm other findings, as further glimpses of the students' mathematical journeys, and as evidence of directly accessing indicators of affective responses to mathematics (described in section 4.4.1), or student identities (described in section 4.4.2).

The students also filled in a questionnaire at the end of Year 10 (see Appendix C) to monitor their overall response to mathematics in terms of positive and negative feelings, to gauge their feelings about the end of year examinations in comparison to their other subjects, and to respond to themes that had arisen during the research process. For example, students were asked about the differences between mathematics and other subjects, and how they felt about seating plans in direct response to discussions in the interviews.

#### **4.4.4 Metaphors for mathematics**

To gather further evidence of students' relationships with mathematics, students were asked to describe mathematics using metaphors. Metaphor is the concept of understanding one thing in terms of another. In mathematics education, metaphors have been used to gather students' affective views by Buerk (1996) and Miller-Reilly (2006). Both researchers found metaphors to be a useful alternative to interviews for collecting rich data.

For this exercise, students were asked to compare mathematics to everyday objects such as buildings or food. The verbal prompts of the tool used in this research were adapted from Buerk's (1996) protocol for the collection of metaphors and are reproduced in Appendix B. One hour of class time was provided for this exercise. I read aloud verbal prompts and students individually wrote their answers to the prompts onto a designed form.

#### **4.4.5 Images of mathematicians**

This research has attempted to understand aspects of students' views of mathematics through capturing the images students' have of mathematicians. The decision in this research to ask the students to draw a mathematician was also made to ensure breadth of research tools. The students had completed the mathematics autobiographies (section 4.4.3) the previous mathematics lesson, and some of the individual interviews had already taken place. By asking the students to draw a mathematician it was hoped to offset some of the issues with interviewing students and asking them to respond in writing. Indeed, several of the students were monosyllabic in the interviews and wrote little for the questionnaires, but their pictures of the mathematicians were drawn in detail.

In this research, students were given a blank sheet of paper with the instruction 'draw a mathematician'. There were no further instructions and they were given fifteen minutes to complete the activity. The students' images of mathematicians were qualitatively analysed as a class set of responses to gauge any general themes and then added to each individual's file of data to be studied in context with other instruments about that person.

#### **4.4.6 Personal journey graphs**

In Year 11, the students reflected on their journeys through mathematics by completing personal journey graphs. These were designed to help students describe how their relationships with mathematics had changed over time to form their mathematical journeys. The concept of the personal journey graphs were adapted from Anderson (2005). She used a similar graph as an instrument in a case study that followed one teacher through the implementation of the New Zealand Intermediate Numeracy Project. A narrative framework was used and data gathered about changing attitudes and beliefs, mathematical and pedagogical content knowledge, and knowledge of student learning in numeracy. The Personal Journey Graph was drawn to reflect the teacher's "opinion of her ability to

implement the approaches consistent with the Numeracy Project in her mathematics classroom” (p. 98). The teacher was asked to draw a curve that represented her implementation ability over time as low, medium or high. She was given the opportunity to reflect on and make changes to her graph at the end of the following year. The graph showed the teacher’s initial confidence waning and then rapidly increasing in the latter half of the year allowing a unique insight into the teacher’s reflections of her journey.

The personal journey graphs also provided an opportunity for the students to highlight significant experiences that affected them in their mathematical journeys. The interviews conducted the previous year revealed the often strong, influence of previous mathematics experiences on their current relationship with mathematics. The personal journey graphs allowed me to see if, the following year, the students felt as strongly about the experiences discussed in the interviews and allowed some triangulation with interview data. Furthermore, the personal journey graphs provided catalysts for further interview questions, and for discussions about the differences between students’ overall feelings about mathematics and the specific feelings they encountered during mathematical activity. This is discussed further in section 6.1.

The personal journey graphs were drawn on large A3 sized paper. Students were asked to graph their feelings of mathematics against the axis labels ‘very good’, ‘neutral’ and ‘very bad’. They were asked to write as much information on the graph as they could to identify the reasons for their decision on where to draw the graph. The students drew the personal journey graphs while seated in small groups. Although the students produced individual graphs, their group discussion was audio-recorded. This lent further relevant data to the research because the students often gave only a summary of their decisions on the actual graphs.

The graphs were analysed both as a class set and as a component of the student’s individual data sets. To establish the percentage of time the students felt positively about mathematics, the length of time a student was positive, neutral and negative in proportion to the total length of the graph was measured and the percentage calculated. This was also done separately for the years prior to Year 9 and 10. Year 11 was excluded from these data because the graphs were drawn only four months into that year. The research showed that students’ feelings became more positive and their engagement generally increased for a time at the beginning of the year of their new class placement.

There are a number of issues with using this research tool and data it generated. These percentages only reflect the students' views at one particular time and they might be different if they drew the graphs on another day, at another time of day, or with different or no other students present. The percentages calculated also do not reflect the intensity of the feelings of the students.

#### 4.4.7 School documents

A variety of school documents were collected (see Table 4.4 below) to help to provide potential glimpses of students' relationships with mathematics and evidence of events and experiences that were potentially significant to the students within their mathematical journey. These can be considered to be stable, institutional artefacts. They are produced for other reasons than the research, and are therefore 'objective' products of the school context, grounded in the real world (Merriam, 1998). They were used with caution, as they were only potentially significant to the individual students and therefore may not have contributed to their relationship to mathematics or their mathematical journey.

**TABLE 4.4 School documents used in the research**

Enrolment information	When students initially enrolled at the school, the contributing school sent a standard form, the parents filled in an enrolment form, and an interview conducted by a dean at the school with the student and their parents, which was recorded on a standard form. These forms were included in the research as they often contained judgements about the student in terms of their academic ability, their social groupings, and their behaviour. Mathematics was directly referred to on these forms. Students often related their affective responses to previous experiences and the enrolment information sometimes gave further detail about those experiences.
Mathematics class attendance	Attendance information was collected to help understand the influence of student absences on their affective responses to the mathematics and the associated stories the students told about mathematics. The decision to collect this information was made in response to the stories of the personal journey of Colin (section 7.1). Attendance records and the reasons for the absence were accessed

	<p>from the school office. Often, a student was absent for part of the period because of extra-curricular activities and this was not recorded in the school absence system. I noted student absences or partial-absences during observations.</p>
Assessment results	<ul style="list-style-type: none"> <li>• Progressive Achievement Tests (PATs) for Year 9 and 10.</li> <li>• Formative assessments Years 9,10, and 11</li> <li>• End of year examinations Year 9,10, and11</li> <li>• Unit and achievement standards internal and external</li> </ul>
Reports	<p>Twice during each school year the teachers formally gave feedback about the individual students to their parents and the school through writing a report. These were based on assessment results and other judgements such as how well the students demonstrated the essential skills, their absences, and homework behaviour. Both mid-year and end-of-year mathematics and English school reports were collected for each student during their enrolment at the research school.</p>
Prizes	<p>Every year, based on the end of year school examinations and teacher judgements, students may receive a Progress or Honours award. Only 2-3 students are eligible for an Honours award in each year level. The school prize giving lists were collected for Year 8 to Year 11. It was important to see in which subjects each student was deemed by the school to be achieving or excelling in to link with other data.</p>
Subject choices	<p>At the end of Year 10 the students were asked to indicate which mathematics class level they wished to enter. Their teachers, based on their end of year exam results and using their own professional judgement, were asked to recommend which class would be best for each student. On the basis of this, a letter was sent home to each student indicating which mathematics class they should take the next year. At the start of their Year 11 they were automatically entered into this class. Some changes were made as a result of parents or students contacting the school. At the end of Year 11, the students were asked to indicate which, if any, mathematics classes they would enrol in the following year. In September they indicated their initial choice. In January the following year, the dean, on the basis of</p>

	the students' exam results, the students' choice and with approval from the head of department of mathematics, approved their courses, and these data were included in the research.
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## 4.5 Analysis

There were three stages of analysis in the research process.

- Stage one: Third column analysis
- Stage two: The students' relationship with mathematics
- Stage three: Individual mathematical journeys

All of these stages occurred both during and after data collection, and therefore all stages contributed to decisions made during data collection. Furthermore, these stages were not done linearly and were re-visited throughout the research process.

### 4.5.1 Stage one: Third column analysis

The first stage of analysis was the initial interpretations made during data collection. These interpretations consisted of “thoughts, musings, speculations, and hunches” (Merriam, 1998, p. 165). These interpretations were added to throughout the data collection and analysis and included methodological decisions and directions, reflections on my interviewing skills, and musings related to all of the research questions. Affective responses and potential identities were noted. The interpretations were shaped by my own background and experiences (described in section 1.5), the literature associated with this research, data already gathered in the research process, and the emerging findings from all of the stages of analysis in the research. In both this initial and subsequent analysis, I remained conscious of seeking alternative explanations, or discrepant evidence. Decisions made about each stage of the data collection process were grounded in data itself and emerging themes (Strauss & Corbin, 1998).

These interpretations are referred to as ‘third column analysis’ because they were always written in the right hand column of an interview transcript or observation. For school documents and written response data these initial thoughts were written on photocopies of the originals and kept in a file. When data was transferred to NVivo, I continued to add to the third column. Below is a section of an interview transcript between myself, Ruth and Moira when they were in Year 10. The first column contains the name of the person who is speaking. The second column contains what that person said. The third column shows my

initial thoughts about the interview during the transcription and some of the subsequent reflections made throughout the research process.

Naomi	That Algebra Starter the other day...	Following up from other interviews and the observations because so many students affected by it. Is this too much of an opener? Should I have let them bring it up themselves?
Ruth	(Ruth interrupts Naomi). We just about fell off our chair (Ruth and Moira laugh). We looked at it and we were like WOW	Check video to see if they were captured nearly falling off their chairs. How did they react? An affective response here but is it necessarily negative? Why did they laugh? How did they feel next time they came across a starter and/or algebra? Is this significant? Ruth is using the word 'we' ... she seems to be thinking collectively. Some sort of justification? Search for 'we' for Ruth and other students. Is 'we' only used in group interviews? What does this mean? Do the top-group students use this word? When do they use it? Need to collect data relating to Algebra starter. What did the teacher think? How has Ruth and Moira's close relationship in Year 10 affected their learning/affect/identities throughout the two years? Check to see if they sit next to each other in class. What happens when they don't sit next to each other? Collect in the students' exercise books where they commonly do their starters, and use these and my observations to specifically ask them in the individual interviews about the strategies they used when they engaged in a specific mathematical task.

#### 4.5.2 Stage two: The students' relationship with mathematics

The analysis at stage two sought to understand students' relationships with mathematics and how these were associated to students' mathematical learning. This analysis was done at a class level. I needed to first understand the class relationship with mathematics to understand the context of the development of individual student's relationship with mathematics.

I used aspects of a grounded theory approach to analyse data. On entering data into NVivo, I reflected on what it told me about students' relationship with mathematics and the association between that relationship and mathematical learning. As discussed in section 2.1, achievement data was used as one of many indicators that learning had taken place because such data may have been more a result of factors such as the student's affective response to the situation, the immediate context of the assessment, or their experiences in the learning of that topic.

Furthermore, it could not be assumed that an assessment result was significant to the students' mathematical journey (section 4.2), though it may have been. Rather, the students'

perspectives of the associations between aspects of their relationship with mathematics and their learning were explored in this analysis.

To analyse data, I loosely coded possible themes, or concepts. NVivo software supported this grounded theory approach by facilitating the coding of data according to developing categories. The coding, labelling using the register of the students, and re-coding and re-labelling of concepts was done using NVivo's system of tree nodes and child nodes. In NVivo coded categories are linked directly with the original data allowing the accumulation of evidence towards that category. This process is called open coding "because to uncover, name, and develop concepts, we must open up the text and expose the thoughts, ideas, and meaning contained therein" (Strauss & Corbin, 1998, p. 102). The analysis phases were not done consecutively, and therefore this process took place throughout the months of data analysis. Although, at the beginning of this analysis, there were few preconceptions about previous research, over time, more understanding of the conceptualisations of the theoretical background of the affective domain may have influenced some of this coding. For example, students' views of mathematics had emerged as an important category, and, as understanding of the beliefs literature grew, this was explored further to form sub-categories about students' views of mathematics, mathematics teaching and learning.

Consequently, data were consolidated and reduced. Merriam (1998) described this process of going back and forth between the concrete and the abstract as a meaning-making process (Merriam, 1998). Collected in another part of the NVivo software were data related to that code. These codes were labelled and re-labelled, grouped together, and developed, gradually forming categories. Seven main categories developed stability.

1. Views of maths
2. Being good at maths
3. Feelings
4. Family
5. Classmates
6. Teachers
7. Engagement

Once main categories formed, these categories were developed further through a combination of the use of searches within NVivo for the use of certain terms, by scanning the documents for potential linkages, and by further, inductive data collection. These categories became further understood by explaining the "when, where, why, how, and so on of a category that is

likely to exist” (Strauss & Corbin, 1998, p. 114). Sub-categories emerged for each of the six categories. The category of *classmates*, for example, came through very strongly in the analysis of students’ feelings, views of mathematics, and their identities. For this category, further analysis was done on competition, physical seating arrangements, who a student sat near, classroom norms around help-seeking and -giving, and student talk. Other categories and sub-categories interacted with these; for example, a teacher’s positioning of classmates through their interactions affected students’ feelings about mathematics. With a gathering complexity and level of detail, a structure of relationships emerged.

### **4.5.3 Stage three: Individual mathematical journeys**

The students’ individual mathematical journeys were explored by capturing their unique relationships with mathematics over time through case studies. A *case study* observes individuals in detail, examining in depth, events, activities and processes and individuals (Stake, 2005). The data set for each student was separated out from the main body of data. This data set contained their interviews, observations about them, their questionnaires and other written responses, their school documents, their assessments, their parents’ questionnaires, and other artefacts such as newspaper clippings. Also included in this set were excerpts from interviews where the student was referred to by their teacher or their peers as well as general comments about the class, school and cultural communities the student participated in. Importantly, all the third column analysis of general thoughts, and potential affective responses and identities pertaining to the student were included in this data set.

Once the data set was assembled, it was read through in its entirety. The students’ mathematical journey was chronologically mapped in terms of experiences significant to them, and the internal themes of their relationship with mathematics. Students’ affective responses to mathematics were identified in data (section 4.4.1) and investigated in relation to surrounding actual and designated identities (section 4.4.2).

To understand how typical each student was – what was the same and what was unique about them – they were compared to the class as a whole. In other words, the internal themes unique to each student were considered in relation to the class’s relationship with mathematics (section 4.5.2). Through constant comparison the analysis moved to and fro between the general and the specific (Strauss & Corbin, 1998); between gradually unfolding personal journeys of the students and the emerging tentative theorising of the students’ relationships with mathematics.

## 4.6 Reporting the results

The elements in a student's relationship with mathematics were complex and interacted with each other. Students' views of mathematics as a boring subject, for example, were strongly associated with their dislike of the subject. It was therefore difficult to write the chapters relating to results in a linear way. Indeed it was difficult to report the results of the investigation when the collection and analysis has not been linear. The reader should be mindful that decisions have been made about what to include when writing the thesis.

Even when emphatic and respectful of each person's realities, the researcher decides what the case's own story is, or at least what will be included in the report (Stake, 2005, p. 456).

Although care has been taken in the design and execution of this study to ensure its quality, this research is not reliable. Other researchers may interpret the data set differently because of their different theoretical positions and their previous experiences. Other researchers may have chosen to report or highlight different aspects of the findings. My role was neither neutral nor impartial and my own perspectives and experiences shape the decisions made in the design, the execution of the research, and the interpretation and reporting of the findings.

Data which pertained to an individual student was labelled and reported in this thesis using a structure derived from Sfard and Prusak's (2005a, 2005b) research (seen already in section 4.4.4). This structure is  $A_{BC}$  where A is the narrator of the story, B is the methodological tool being used, and C is the year level the research class was when the story was told. For example, Amanda said the following statement during her individual interview in Year 10 and it has been identified as such.

Mum thinks [maths] is very good for me to learn (Amanda<sub>InterviewYear10</sub>)

This identification structure allows data to be viewed in the context of when and how it was collected. If a quote has been used in reporting this research, unless otherwise stated, the reader should assume that it is both endorsed by the student it is about, is supported by other data, and it represented the view of the group of students under discussion. Departures from this view are noted, if relevant. In the transcription, a gap in the commentary was marked with "...", and any interpreted text is denoted by square brackets.

The names of the awards have been changed to Progress, and Honours at prize-giving to differentiate them from Achieved, Merit and Excellence grades in NCEA. The names of the mathematics classes at Year 11 have also been changed to reduce confusion.

## 4.7 Conclusion

This chapter outlined the methodological design of the research and, within this, detailed how data was collected and analysed throughout the research, in order to answer the research questions. This research has a qualitative framework using ethnographic and case study techniques to fully describe the classroom, the sociocultural context of the students.

Strategies have been used throughout this research to ensure its quality such as minimising researcher bias through intensive, long term involvement, validating responses through checking directly with the students, searching for discrepant data, negative cases, and seeking alternatives. This research uses multiple sources of data, or multiple methods to provide further evidence and confirm the emerging findings (Merriam, 1998). The supervision team reviewed the transcripts, analysis, and drafts of the thesis. Transcripts were constantly referred to and checked for consistency in interpretation throughout the stages of the analysis (see section 4.5). The breadth of the data enabled triangulation to take place.

A grounded theory approach has been used to analyse data and present a cohesive report of students' relationships with mathematics, the association of these relationships with mathematical learning, and the changes in these relationships over time. This chapter described how fleeting glimpses of data, the lit windows on the train, were used to capture the complexity of adolescent students in school mathematics classrooms. The phases of data collection and analysis are described in a linear fashion. In reality, the data collection and analysis has moved back and forth between the phases, between the individual students, between the years, and between data, the structure of school mathematics, and the emerging relationships between students' mathematical journeys, affect and identities.



## CHAPTER FIVE: School Mathematics

The students in this research had complex and dynamic relationships with mathematics, which changed over time to form their mathematical journeys. Informed by the literature and the methodology detailed in the previous chapters, Chapters Five and Six explore the key elements of these relationships. Chapter Five discusses aspects of students' engagement in the mathematics and their views about the subject, and Chapter Six explores students' feelings and identities. These emerged from analysing the students' responses as a class set (section 4.5.2) and therefore they have been described in terms of the whole class in Chapter Six. Chapter Seven explores the unique mathematical journeys of four students.

This chapter explores the students' views of mathematics and how they associated these with their learning and engagement. The chapter details what school mathematics meant to the students in terms of its nature and importance. The dominating student perception of mathematics as a difficult and boring subject is then examined.

### 5.1 Learning and engagement in school mathematics

The students did not explicitly define mathematical learning in this research. Indeed, the students rarely used the term 'learning'. When they did, it was used as a verb for the accumulation of mathematical content knowledge – the facts, symbols, concepts, and rules in school mathematics. The word 'learning' was followed by what the students were learning. In other words, the students always associated learning with the accumulation of content.

I got to learn my basic addition (Ben<sub>InterviewYear10</sub>).

When we are learning algebra it makes me excited. When we are learning something new it makes me excited (Colin<sub>InterviewYear10</sub>).

Maths is largely about learning different rules and formulas and what not (Angela<sub>GroupInterviewYear11</sub>).

Rather than talking about learning when discussing aspects of their relationship with mathematics, students more often talked about aspects of their engagement, for example “working” or the “doing” of mathematics. Sometimes they used these terms synonymously to

“learning”. The students perhaps assumed that, if they engaged in mathematical activity, they would accumulate mathematical content knowledge, and learning would take place. For these students, engagement was necessary for learning.

We learn maths ... by doing it (Ben<sub>MetaphorYear10</sub>).

I can work better with like noise or music ... it's easier to work ... to learn  
(Susan<sub>InterviewYear10</sub>).

When we had that teacher [long pause] I didn't do ... learn anything  
(Connor<sub>InterviewYear10</sub>).

To actually start learning you had to wait like 15 minutes for the trouble-makers to be  
[sent out] (Sean<sub>GroupInterviewYear11</sub>).

People ... who can't be bothered trying, are doomed to fail at maths  
(Katrina<sub>MetaphorYear10</sub>).

This connection the students made between their engagement in mathematical activity and learning is consistent with the findings of other researchers. Boaler and Greeno (2000) defined learning as participation in the practices of school mathematics (section 2.3). Similar to the comments made by the students, Yair (2000) defined engagement as paying attention to instruction and stated that engagement was a necessary condition of learning.

If [students] do not focus on the immediate instructional context, they will not experience instructional opportunities or gain from the potential effects of these opportunities on their achievements, knowledge, and interests ... If they do attend to instruction, they are likely to learn something (Yair, 2000, p. 248).

Williams and Ivey (2001) suggested using engagement in the activities of the mathematics classroom, rather than achievement, as an indicator that learning is taking place.

Engagement in lesson activities is both more directly under the control of a student, and more readily observable, than is achievement. Achievement standards vary from room to room and district to district, and certainly between conceptually based and traditional classrooms, but the behaviours related to engagement in classroom activities are more universal (Williams & Ivey, 2001, p. 77).

As discussed in section 4.1, it is the students' perspectives of their learning and engagement that are sought in this research. Although the students never used the word 'engagement', this was the name given to the category that emerged in the analysis of the research (described in section 4.5.2). It was different to 'participation', which was already used to describe students choosing to participate in the subject of mathematics as a whole (as in section 1.3 and section 6.2.1). *Engagement* included a range of expressions about students' involvement in the mathematical activity of the classroom and their commitment to learning the mathematical content. Corrina, for example, talked about "concentrating" in the mathematics lessons. Connor described his disengagement by talking about "gurning around". Mark described his engagement in the lesson starter.

I need to concentrate more in maths ... trying to get it (Corrina<sub>InterviewYear10</sub>).

It took a while to adjust ... at the beginning of the year. I was just gurning around. [Naomi: Gurning?]. Slothing ... mucking around (Connor<sub>GroupInterviewYear11</sub>).

If I take a long time to get my stuff out [at the start of class] or write the [starter question] out slowly ... [if] it's just a quick warm up thing I don't really try that hard ... sort of because then [at the end] I can just write down what he's already written or [the answer] people call out (Mark<sub>InterviewYear10</sub>).

The following list contains further examples of terms the students used to talk about their engagement, many of which are used throughout Chapters Five, Six, and Seven.

Being slack, giving up, not focused, avoiding, trying, doing the work, working hard, paying attention, persevering, striving

Closely related to this, when the students described their engagement, or less frequently their learning, they often described directly or implied different levels of *motivation* – their feelings of wanting to engage in the work.

I didn't really feel motivated to do it at all (Katrina<sub>InterviewYear10</sub>).

Yeah ... I don't study. I just can't be bothered doing it (Bridget<sub>InterviewYear10</sub>).

There was also a variety of ways students had of describing their motivation to engage. These are evident in student quotes or extracts from interviews in Chapters Five, Six, and Seven.

Can't be stuffed, just don't want to do the work, excited to learn, enthusiastic, having the oomph to figure something out.

Affective researchers (e.g., Malmivuori, 2006) included habitualised behaviours and patterns of engagement in their conceptualisations of a students' mathematical core. Indeed, there was evidence the students had *habits of engagement* in the subject of mathematics –their involvement and commitment to the subject overall.

I don't try to learn it. I just let it go straight through me (Paul<sub>GroupInterviewYear11</sub>).

I try and like see what we'll be doing in the next week. Otherwise ... so that I'll understand when we do it. That's what I've been doing with those  $y = mx+c$  tables. I remember [the teacher] saying graphs so I thought I'd get [the textbook] out to work out what we were going to be doing (Moir<sub>InterviewYear11</sub>).

The ways students usually engaged in each mathematical task were part of students' habits of engagement. Goldin's (2004) use of the term 'affective pathways', described in section 2.3, has been adapted to talk about students' *pathways of engagement*. Although the students' feelings did carry meaning about their progress in a task (section 6.1.2), as described by Goldin (2004), there were other factors that played a role in the different ways the students engaged. The term 'pathways of engagement' is used because more than affective factors are considered in this research. The students describe in the following stories how they usually solved a mathematical task. The pathways of engagement the students described could be classified as *avoidance*, *superficial engagement*, or *full engagement*.

If a mathematical task looked hard, some students avoided doing it altogether. They disengaged before attempting it.

I find some things easy but others I just don't even attempt (Debbie<sub>EndofYear10</sub>).

The students described what they did instead of engaging in a task. Mark, for example, pointed out 17 games of 'Connect 5' in his exercise book (section 4.4.1). Ruth, who is a case-

study in section 7.4, spent a lot of time texting on her cell-phone during the mathematics lesson.

Look at what I did today. No maths (Mark<sub>InterviewYear10</sub>).

If I'm sitting there, I'll just start texting somebody (Ruth<sub>InterviewYear10</sub>).

Similar to Mark and Ruth, other students described a variety of ways they avoided doing the mathematics.

Going to the toilet, ruling up pages in their exercise books, organising their equipment, programming their calculator, eating, daydreaming, writing notes to each other, writing poetry, doodling, talking socially.

Some students talked about only engaging superficially in mathematical tasks.

I try and figure [the problem] out ... after a wee while if I really can't do it at all, I just give up (Bridget<sub>InterviewYear10</sub>).

If it's really hard I'll try and think about it and if I don't get it like I'll go just straight to the answer, yeah (Moir<sub>GroupinterviewYear10</sub>).

These students often asked for help as soon as they became confused with a problem.

I'll try it but if I can't do it the first time I'll go and ask for help (Debbie<sub>InterviewYear10</sub>).

When I'm stuck ... I always ask for help when I'm stuck. I don't kind of waste of time thinking about it (Jason<sub>GroupinterviewYear11</sub>).

[When I come across a hard problem] sometimes I just don't bother doing it because I'm too lazy. I'll ask Katrina, or if she doesn't know the answer I ask the teacher sometimes ... if I can be ... if I really need to know, then I'll ask the teacher. If it's not like completely necessary then I don't bother (Susan<sub>InterviewYear10</sub>).

These students sought help because they were unprepared to think more deeply about the problem. It was a habit to ask for help rather than to persevere with the work. Seeking help in this case was a form of disengagement or avoidance. These students were focussed on getting

the correct answers quickly, without effort, and did not show commitment to the learning process.

Some students described full engagement in mathematical tasks. These students thought about the processes of solving the task, and they persevered, using a variety of strategies, and often discussing the mathematics with others.

If I come across a hard problem I will sort of think how I would solve it, and do it in steps (Connor<sub>InterviewYear10</sub>).

If I come across a really hard problem if it's at home, if I remember we've done it I look in my maths books or my homework maths book. I could find it on the internet if I wanted. I'd ask someone sitting next to me, or the teacher (Frank<sub>InterviewYear10</sub>).

I usually divide it into sections to do so I'm not tackling the whole thing at once and trial and error sometimes is involved ... Think about possible options (Angela<sub>InterviewYear10</sub>).

I'll read it a couple of times and think about it logically and sort of see what it actually means ... because sometimes they look harder than they actually are. I talk to some other people about it ... see what their methods are and stuff (Katrina<sub>InterviewYear10</sub>).

Frank and Katrina have been described as fully engaged when they were discussing mathematics with others. They are different to the students with superficial engagement who asked for help immediately, described above. Asking for help or discussing the problem with others was one of a range of strategies Frank and Katrina used when they became confused. They were not dependent on help as their only strategy for solving the difficult task. This is discussed further in Robyn's case study in section 7.3.

In mathematics education research, Sullivan et al. (2006) identified classroom culture as an important element in students' engagement. Furthermore they noted that, for a student to have successful participation in mathematics, the students needed to have the requisite prior knowledge, the curriculum needed to be relevant to them, the classroom tasks needed to interest them and the pedagogies and assessment regimes needed to match their expectations. In other research, Yair (2000) attributed a student's disengagement to their preoccupation with external contexts, self-consciousness, or their involvement in the social aspects of the

classroom. The current research found there were many factors both external and internal to the classroom that the students attributed to their engagement in the mathematics. Students' individual and complex lives continued in the classroom and, according to the students, affected their engagement. For example, tiredness or problems at home contributed to some students finding it more difficult to engage in mathematics.

I've been doing [the school show]. I hate doing maths when I'm tired. Sometimes it's hard to concentrate (Jill<sub>MetaphorYear10</sub>).

Connor was affected by his home-life, which had been very difficult that year.

I sort of [have] been working on and off all year because different things have been happening at home (Connor<sub>InterviewYear10</sub>).

Last year Connor got Excellences the whole year ... and this year [probably because of things at home] he's struggling to get Merits ... his whole attitude has changed quite a lot (MrsBrown<sub>InterviewYear10</sub>).

Similarly, examples of other reasons the students gave for disengaging in mathematics were:

Parents divorcing, romantic relationships, issues with friends, after-school jobs, disciplinary action from the school, family illness, New Zealand rugby team playing against Australia, imminent assessments in other subjects, low energy due to lack of vegetables in diet.

The students also described conditions within the classroom as affecting their engagement. Debbie, for example, described how the temperature of her mathematics classroom affected the amount of work she did.

It's always that hot in that class. Yeah, before I walked into that class I didn't have a headache. I got into that class ... I got a headache and was augh. I did nothing after that (Debbie<sub>InterviewYear10</sub>).

Ryan and Patrick (2001) described the social environment of the mathematics classroom to be particularly important in terms of motivation and engagement of adolescent students. Socio-cultural norms, influenced students expectations of when learning should occur.

Last period on a Friday. Huh! We don't do anything then (Dawn<sub>InterviewYear10</sub>).

The social nature of the students and their level of off-task behaviour, meant that classmates affected students' engagement. According to the students, classmates near them who were behaving in a disruptive manner easily distracted them from their work. Ben wrote his comment in response to a questionnaire at the end of Year 10.

If I am next to people who didn't concentrate on their work and were loud ... it would be hard to concentrate (Corrina<sub>InterviewYear11</sub>).

Who I sit next to totally affects me. I don't do anything. I find it hard to focus. I get distracted really easily (Maira<sub>InterviewYear10</sub>).

If I'm sitting next to someone who works hard, I'll work hard. If I'm sitting next to people that don't, I just won't (Susan<sub>InterviewYear10</sub>).

My friends distract me (Ben<sub>EndofYear10</sub>).

There was a sense that the students largely felt powerless to control others' behaviour and could only work if their classmates' behaviour allowed it. The students relied on their teacher to control their classmates and their own behaviour.

Mr Murray ... could not control our class and ... I did one page of work [for the term] because I was just talking all the time. It would worry me if it was [like that] all the time (Tracey<sub>InterviewYear10</sub>).

[A maths teacher should be] someone who's strict but not too strict. We actually want them to be a wee bit strict (Joanna<sub>GroupInterviewYear11</sub>).

I need a cattle prod (Susan<sub>GroupInterviewYear11</sub>).

As discussed in section 1.4, these 13-15 year old students had entered adolescence with mercurial hormones and strong, social expectations relating to their need to belong (Wigfield et al., 2006). In the same way as the students described in Hannula's (2006) research, these students experienced strong social needs that conflicted with their need to engage in the mathematics. In Year 10, the students were already settled into social groups, but these

changed and mixed as students became more confident with the opposite gender. By Year 11, the students' need to be social had developed and intensified.

There's more like the puberty thing [in Year 11]. People more like to have sex and have boyfriends and girlfriends and that's where the focus of school is. You're meant to be focussed on school (Saskia<sub>InterviewYear11</sub>).

In Hannula's (2006) conception, students' social needs can lead to goals or behaviours that are not necessarily in conflict with students' academic needs. If a student is helping their classmates, or seeking to please their teachers or parents, these meet both their social and academic goals. There is tension among these students because of the way they try to meet their social needs.

These factors, which might be considered to be external to mathematics, are often not considered in affective research (e.g., DeBellis & Goldin, 2006). Any discussion of a students' engagement, however, cannot isolate these factors because students' learning is situated within the context of the mathematics classroom and the students' lives. Rather than being external to their learning, their lives were part of their learning of mathematics. When the students engaged in a mathematical task, therefore, they were each situated in a unique *context of the moment*. Even when they were experiencing the same classroom conditions – the same teacher, at the same time of day – the students each interpreted the context in a unique way, and this interpretation led to different ways the students' engaged in the mathematics.

In summary, the students' perspectives of their engagement – their commitment or involvement in the mathematics – emerged as an important category in this research. The students viewed their engagement to be necessary for learning to take place. Students described both their overall engagement in the subject of mathematics – their habits of engagement – and their pathways of engagement – the way they usually engaged in a mathematical task. The students' pathways of engagement could be described as avoidance or disengagement, superficial engagement, or full engagement.

Students' engagement in the mathematics was affected by other factors both internal and external to the classroom. For these students, their lives were part of their mathematical learning and contributed to the unique context of the moment when the students engaged in a

mathematical task. Throughout Chapters Five and Six other associations the students made between their relationships with mathematics and engagement in the subject have been described. Specifically, how the students associated their engagement with their views of mathematics, their feelings, and identities are explored. Why some students had full engagement in mathematics, and some only superficial is also explored.

## 5.2 Students' views of school mathematics

Students' views of mathematics are their beliefs or subjective conceptions about school mathematics and mathematical learning. These form part of their relationships with mathematics. The students' views about mathematics were situated in mathematics classroom, and were held because they are members of the classroom community, and because of their families and other communities they were associated with. Consequently, the students in this research had views that were common to the majority of the class, but each student had subtle variations of these views. In this section I detail the students' views about the nature of mathematics, the importance of mathematics, and their perceptions of mathematics as a difficult and boring subject. Woven into this discussion are comparisons the students made between mathematics and their other school subjects. How the students associated their views of mathematics with their engagement in the subject is then described.

### 5.2.1 The nature of school mathematics

The students generally defined mathematics to be the process of using numbers, symbols, rules, formulas or patterns to solve problems. Mathematics was seen as an exact science with strict procedures (rules), a strong, logical structure, and problems that had only one correct answer. This made mathematics different from other subjects that emphasised creativity and sought alternative answers.

Mathematics is following rules/patterns (*Ann<sub>MetaphorYear10</sub>*).

Mathematics is logical and scientific ... working with everyday problems to come up with solutions (*Lola<sub>MetaphorYear10</sub>*).

In other subjects you can be a little more creative with your answer (*Corrina<sub>EndofYear10</sub>*).

Dawn: In English you can sort of do ... a lot of it is what you think. Your opinion.  
Mathematics is more ...

Lola: ... exact (DawnLola<sub>GroupInterviewYear11</sub>).

Many of the students' views of school mathematics were related to the subject's routines. In the students' view, the routines of the mathematics classroom did not vary from lesson to lesson and, indeed, had not significantly varied since they began secondary mathematics in Year 9. Nor did they vary as the students moved, during the research period, from Year 10 to Year 11. The students described these routines in some detail. At the beginning of the mathematics lesson there was usually a starter activity or problem, during which homework was checked. The teacher then reviewed previously-taught content or explained new content. The teacher might at this stage ask questions to check for understanding. The students were shown at least one example of a problem related to the new content, and then were asked to copy notes from the board on the new content and the procedure for solving problems associated with that content. They then worked on exercises from the textbook related to the content, writing their answers in an exercise book. The students were encouraged to mark their work using the answers at the back of the textbook, and ask for help from their classmates or the teacher if they did not understand. This activity took up the main proportion of the lesson. If the student wanted help from the teacher they raised their hand and waited for the teacher to respond. Mathematical discussions were rare, and generally only related to help seeking, as discussed in Philip's case study in section 7.2. At the end of the lesson, the students were generally assigned homework.

Sometimes I would talk to them and we'd do some together and then try some in the textbook or sometimes it's me just telling them (Mrs Brown<sub>InterviewYear10</sub>).

In maths it's usually the starter, something new, exercise work and usually that until the end of class and then there's homework. It's quite a routine (Corrina<sub>InterviewYear10</sub>).

It's like every day we have to get our textbook and go through the book. We don't play games or anything (Connor<sub>InterviewYear11</sub>).

In Shannon's (2004) case study of one student in New Zealand, a dominant discourse emerged that mathematics was taught differently to other subjects and that mathematics classrooms operated in ritualistic ways. Indeed, the students described the routines of the mathematics classroom as unique from other subjects learnt at school. Students described other subjects as having less new content, less repetition of topics, and more variety. In other

subjects, the teachers frequently included methods such as role-plays, small group work, class discussions, posters, and debates as well as individual work.

Maths is different [from other subjects] because the learning format is different ... you basically learn new things everyday then apply your new-found knowledge to exercises (Angela<sub>EndofYear10</sub>).

In maths there is ... less discussing things (Jennifer<sub>EndofYear10</sub>).

In science you have like experiments and analysing your experiments and results whereas in maths it's just practice, practice, practice (Angela<sub>GroupInterviewYear11</sub>).

The teacher comes into the room said, right here's a new topic, here write these notes and turn to page 37 and do 1,3,5,7. Maths teachers do that more than other teachers. Yeah, they feel like they can. They don't really feel like they need to explain it. Actually, it would be useful if they did because if you knew why you were doing something it would help you remember how to do it (Alasdair<sub>GroupInterviewYear11</sub>).

The students' descriptions of school mathematics and its routines are consistent with many classrooms described in mathematics education research. According to Brown et al. (1989) mathematics is traditionally taught as well-defined, independent and abstract concepts able to be explored in prototypical examples and textbook exercises. Beswick, Watson, and Brown (2006) describe a traditional classroom in their research as teacher directed, where the students undertake routine exercises. In Stodolsky's (1985) research, similar to the routines described by the students in the current research, the mathematics lessons had few concrete and manipulative experiences and a lack of social support such as group-work or discussions in comparison to other subjects. Indeed, the students in the current research believed that mathematics was intended to be a solitary activity, done by individuals in isolation with little opportunity to work with classmates. The routines formed part of the socio-mathematical norms shared by the classroom community (as defined by Yackel & Cobb, 1996). They are part of the didactic contract described in section 2.2 – a mutual understanding between the students and the teachers of what constitutes mathematics learning and teaching in the classroom.

The way a student experiences mathematics in their classrooms is the way they come to view mathematics (Henkin & Schwartz, 1994; Schoenfeld, 1992). The students in this research had

an instrumental view of mathematics where the subject was seen, as described by Ernest (1991), as a collection of rules, facts, and skills. Similarly to Boaler's (2002b) description of a traditional school, according to the students, the teachers in the current research did not discuss their choice of procedure, nor did they discuss with students when or why these rules worked. Furthermore, the students were not encouraged to construct their own methods. There were few opportunities for the independent thought, exploration, and creativity which is synonymous with the collaborative (Burton, 1999) and messy (Schoenfeld, 1985) practices of mathematicians. As Wieschenberg (2004) stated, by providing students with problem solving opportunities, teachers are providing "interesting glimpses into what mathematics really is – a colourful, fascinating mosaic of human achievement" (p. 52). Brown et al. (1989) suggested that, to enter a community, an apprentice must learn to use tools like a practitioner would. Instead of the mathematics of mathematicians, the students of this research were exposed to the rigid procedures and seemingly unwavering routine of school mathematics.

### 5.2.2 The importance of mathematics

The students showed an awareness that both choosing mathematics as a subject to study and success in the subject were important. The students' parents appeared to be significant voices in their views of the importance of mathematics, as demonstrated in the following quotes.

Maths is like the colour red – important, hard to avoid or miss (Katrina<sub>MetaphorYear10</sub>).

Everyone should be encouraged to do maths because maths is a necessary tool for daily living ... most jobs require some mathematical ability, even if it's just filling in the timesheet, or making change, or forecasting sales (Katrina<sub>MumQuestionnaireYear10</sub>).

Dad ... doesn't care about any other subject but he wants me to do like well in maths ... because he said that you need maths once you leave school and stuff ... and I'm like yeah I know that so I try my hardest and stuff. Sometimes it just doesn't work (Debbie<sub>InterviewYear10</sub>).

I am a Diesel Engineer. This is why I feel strongly about the basics in maths, because in my business, if you can't do the basic maths you will never get to a trade position of my kind (Debbie<sub>DadQuestionnaireYear10</sub>).

In these quotes, the parents' views are echoed or re-voiced in the words of the students. Graue and Smith (1996) discussed this notion in their examination of parents' and students' voices.

Using semi-structured ethnographic interviews they explored the meanings 23 sixth grade students and 18 of their parents had about mathematics. Graue and Smith (1996) found parents and their children shared ideas and even language to describe mathematics, linking this to Bakhtin's (1981) notion of ventriloquation "which describes how individuals appropriate others' words for their own use" (p. 294). Indeed, Bakhtin (1981) talked about how a person's ideas may be situated within historical time but they are directed to specific audiences. In other words, what a student says may reflect their families' views but are oriented towards their classmates or the researcher.

Students' meanings of mathematics are shaped by voices representing life histories through past schooling and family lives (Graue & Smith, 1996). A classroom's culture, values, norms and expectations meet, through the student, with those of the home (Lange, 2008b), and this intersection between home and school can be seen in the students' voices above. The parents in this research emphasised the importance of mathematics, and the students, negotiating between the parent and the classroom, often re-voiced the ideas of the parents. Home environments had an impact on, indeed were part of, students' views of mathematics.

Many of the students specifically mentioned the need to know or succeed in mathematics for later in life or, specifically, for employment. They rarely made a connection with mathematics as a skill needed now or throughout their lives.

Yes I know that it is important and will help later in life (Dawn<sub>AutobiographyYear10</sub>).

Mathematics is [for] when you are older you will know how to calculate things (Jennifer<sub>MetaphorYear10</sub>).

Umm, yeah like Dad wants me to like ... he doesn't care about any other subject but he wants me to do like well in maths ... because he said that you need maths once you leave school (Ruth<sub>AutobiographyYear10</sub>).

Maths is just a subject I do in school to help me in my later life when I have a job or own a business etc (Nicola<sub>MetaphorYear10</sub>)

Other students, although aware of the perceived need to succeed in mathematics, were more ambivalent. After reading the students' autobiographies, one of my notes was "It is like these students have had a drink-drive campaign that they are not convinced of"

(Researcher<sub>NoteYear11</sub>). The following quotes from Susan and Mark are representative of quotes from these ambivalent students.

I know I probably should take maths through to Year 13 in order to get a decent job  
(Susan<sub>InterviewYear10</sub>).

I will take maths probably the whole time I'm here because ... you really need maths for [everything]. You don't really use it but it's good to have it (Mark<sub>InterviewYear10</sub>).

Mathematics is like a boring, tedious person that is somehow necessary in our lives  
(Lola<sub>EndofYear10</sub>).

In these quotes, even though Susan does not sound convinced, Mark seemed to contradict himself. Perhaps he struggles with the necessity of learning mathematics when he does not seem to use it in everyday life, or perhaps he is giving what he perceives as the correct response in the interview. Three of the students were more direct (Saskia, Tia, Bridget) and said they did not need to take it through to Year 13 because it was not important. Saskia, for example, wanted to be involved with fashion designing or music when she left school.

I don't know [how long I'll take maths for]. It's like I don't think I'll need that much more maths education because it's one of these extra things I won't be using for the rest of my life (Saskia<sub>InterviewYear10</sub>).

Sullivan et al.'s (2006) research similarly found a substantial number of students had limited perceptions of the value of mathematics, viewing the subject as a school-oriented task only. They described the engagement of students who were unconvinced of the importance of mathematics as "vulnerable to external threat" (p. 90). Sullivan and McDonough (2007) later suggested that, important to students' motivation was "the extent to which students connect current schooling with future opportunities or their possible selves" (p. 700). Skovsmose (2005a) similarly talked about a person having a foreground, which is the person's interpretation of his or her learning possibilities and 'life' opportunities, in relation to what the social, political, and cultural situation seems to make acceptable and available. In his view, these foregrounds set the conditions for students' engagement in, as well as their resistance towards, mathematics.

Educational psychologists would describe a student doing mathematics for the purpose of pursuing a particular career as being extrinsically motivated (section 2.3). This is not as powerful a motivator as when the student is intrinsically motivated. In other words, to be motivated, students need to be doing each mathematical task because of their interest in it, the value they perceive it as giving them, and their perception of whether or not they are able to do the task. Students are intrinsically motivated to do a mathematical task when the successful completion of the tasks helps them to meet the expectations created by their designated identities. This is a problem because as students get older there is less chance that activities will be intrinsically motivating as freedom is curtailed by “social demands and roles” (Ryan & Deci, 2000, p. 60).

There was some consistency with the students’ views of the importance of mathematics, described above, and their drawings of mathematicians. When asked to draw a mathematician, eighteen (over half) of the students drew an Einstein-like male with wild, messy hair and glasses, an alien, or a nerd. Saskia, below, describes a mathematician as wet. In adolescent language this means a dull person.

He has his hair out of place because you are not a real mathematician without it  
(Jason<sub>MathematicianYear10</sub>).

Nerdy, wet (Saskia<sub>MathematicianYear10</sub>).

Four students (Joanna, Amanda, Katrina, Susan) stated that a mathematician could be anyone. Perhaps those students did not, like the others, disassociate mathematics from themselves and accepted society or perhaps they were aware of my expectations in asking them to draw a mathematician.

A mathematician can be anyone. It doesn’t have to be that they’re nerdy looking, have frizzy hair, or have glasses (Joanna<sub>MathematicianYear10</sub>).

Like the students in Picker and Berry’s (2000, 2001) research (section 2.2), many students appeared to rely on stereotypic images of males with glasses, beards and “weird” or balding hair. This is a stereotypic view of a mathematician which may form as a result of their exposure to media and other popular culture (Picker & Berry, 2000). Mendick (2006) described being a mathematician as a culturally and socially marked category of identity. Mathematicians were seen as different. Though they have no direct evidence, Picker and

Berry (2000) suggest that students' dissociation of mathematics from themselves may hinder their study of mathematics and affect their participation in the subject. Indeed, the students seemed to disassociate continuation in mathematics from themselves and accepted society. Continuing in mathematics, at least for these students, seemed neither attractive nor viable.

### 5.2.3 The difficulty of mathematics

The students also discussed the level of difficulty they experienced in mathematics. In class discussions, the students defined a mathematical problem as difficult or hard when they were required to think at more than a superficial level to solve it, or the problem was harder than they perceived they were capable of solving.

Only a small minority of the students found mathematics easier than other subjects. Philip and Paul, thought mathematics was easy because they were "told what to do" by being given specific questions to answer, rather than "in English, [where] you have to think off the top of your head what to do", and there were multiple possible answers (PhilipPaul<sub>GroupInterviewYear11</sub>).

The general view of the class was that mathematics was more consistently difficult than their other school subjects. In mathematics, content and procedures from previous years needed to be remembered. Mathematics was perceived as having a more cumulative nature than other subjects. This, with the routine of almost daily learning of new content and rules, meant the students felt they were expected to know a greater amount of content in mathematics as time went on, compared to other subjects. The students perceived they were expected to know the rules off by heart as well as the content rather than constructing them when they came to a problem. Mathematical rules indeed seemed to be part of the students' mathematical content knowledge.

Maths is ... formulas by the bowlful (Mark<sub>GroupInterviewYear11</sub>)

There's just a lot to maths. There's a lot more than other subjects  
(Debbie<sub>GroupInterviewYear11</sub>).

It's real difficult sometimes to memorise all the different things  
(Angela<sub>GroupInterviewYear11</sub>).

Always more to learn (Katrina<sub>MetaphorYear10</sub>).

It's different [from other subjects] because there are strict rules, which you have to remember (Susan<sub>EndofYear10</sub>).

As Holland et al. (1998) describe, it is the practices of learning mathematics that define the knowledge that is produced. The way single rules had been emphasised in the teaching of the topic may have contributed to the students' perception of mathematical content being a collection of rules.

One of the other ways students regarded the subject of mathematics to be different to other subjects was the pace at which it was taught.

Maths is different. There is really no set pace in art or English or anything like that ... We need [a maths teacher] who goes at a steady pace ... Goes at the pace of the middle person, branching out either way (Peter<sub>GroupInterviewYear11</sub>).

A good mathematics teacher does not rush. They make sure everybody understands it before they move on (Frank<sub>GroupInterviewYear11</sub>).

When the pace of the lessons was too fast, the students missed opportunities to understand and practise concepts.

Joanna: The other thing with maths is that when I get the stuff I [only] just get it and then we move on and then by the next period I've forgotten it. I need to get it and then do heaps of practice.

Debbie: But as soon as you get it they change you onto a different thing. Yeah. And you lose all that stuff that you've just learnt and you have to learn a whole new different thing (JoannaDebbie<sub>GroupInterviewYear11</sub>).

The other way the students felt mathematics was more difficult than other subjects was the proportion of time spent in the classroom on exercises working or figuring something out. This meant the students' general perception was that they had to think more than in other subjects.

Mathematics is all thinky (Bridget<sub>EndofYear10</sub>).

Mathematics is exercising your brain (Alasdair<sub>MetaphorYear10</sub>).

In maths it's harder and you have to think more than in other subjects  
(Joanna<sub>EndofYear10</sub>).

Always questions and answers. It's a lot of working out, whereas in other subjects it's  
a lot of copying notes or discussing things (Jason<sub>GroupInterviewYear11</sub>).

The students in the current research seem to be talking here about two types of difficulty they experienced with mathematics – the proportion of time within a lesson they were required to think rather than listen or write notes compared to other subjects, and the complexity of the subject which required deeper than superficial levels of thinking. This second perception is the one generally discussed in research. The results from the current research are therefore somewhat different from students in Nardi and Steward's (2003) research which described mathematics as a rather mindless task-completion activity that did not require high levels of concentration and where students can talk and work at the same time. Boaler (2002b) similarly describes students as regarding thinking practices to be an unnecessary part of their mathematical experiences. She described teachers as discouraging students to think by reducing a mathematical situation to a procedure the students should learn and remember. They did this to reduce the complexity of the task, exemplify the content, to save time so that the curriculum content could be covered, and to help with classroom management. There are difficulties with this approach, however.

Teachers can, in their haste to impart difficult material, make the process of studying mathematics which in actuality can be hard and messy, look so smooth and easy – like magic (Picker & Berry, 2000, p. 89)

On the one hand, the students referred to learning as the accumulation of knowledge (section 5.1). Reinforced by the routines of the classroom they assumed knowledge could be passively received. On the other hand, the students also talked about mathematics forcing them to think, and they experienced tension when they were asked to think at more than a superficial level of thinking.

Similar to the students in Boaler's (2002b) research, and related to the students' instrumental views of mathematics, the students seemed to seek instrumental understanding. The students therefore perceived they were expected to know the rules and be able to use them to solve a mathematics problem, without necessarily understanding why. Students talked about 'doing'

rather than understanding. With the exception of Colin, whose case is studied in section 7.1, there was a sense that understanding was used with an instrumental rather than a relational meaning. Rather than wanting to understand *why* the rules solved the mathematics, the students wanted to know and be able to follow the rules to *do* the mathematics. Dawn, for example, seemed to equate understanding with knowing how to solve a problem.

Maths is like the wind for me. It's always changing and you never know what it will do. It's like this. You want to go fishing but know you can't because the wind has picked up and the water's rough. Maths is like this you can't do something if you don't know how to do it. You have to understand it (Dawn<sub>MetaphorYear10</sub>).

Furthermore, the students thought there was only one way to solve a mathematics problem, and one correct answer, consistent with students with instrumental goals. Similarly to Brown et al.'s (1989) cautioning that it is possible for students to acquire a tool but be unable to use it and so the tool lies inert, there is danger in students knowing procedures and not being able to use them in the different situations they encounter (Boaler, 2002b). Even though doing textbook exercises, which used the procedures that had just been taught, reduced thinking initially, learning specific procedures made mathematics ultimately more difficult for the students. The students in the current research seemed overwhelmed by the number of procedures they were required to remember and know how to use. When they were exposed to a problem where a procedure they had learnt did not fit or they had forgotten an appropriate procedure, they floundered. Furthermore, the proportion of time the students spent in each lesson answering questions from a textbook using a specific procedure to get a single correct answer meant that many of the students felt that they should understand the mathematics immediately and they experienced difficulty when this did not occur.

When describing students' views of mathematics, an attempt was made to discuss them without making an assumption they were positive or negative in terms of students' feelings. As in Zan and Di Martino's (2007) research, described in section 2.2, there is an assumption in research that a student's vision of mathematics could be linked with different emotional responses. For example, the students generally said, "mathematics is difficult", which was associated with the negative "I dislike mathematics". This association was not always the case. Colin, whose journey is explored in section 7.1, thought mathematics was difficult and relished this difficulty and the confusion he experienced as a result.

## 5.2.4 Mathematics is boring

During the research, the students frequently brought up the concept of boredom; the students mention the concept on 99 separate occasions out of 217 different data sources. All of the students described mathematics as a boring subject, with the exception of Colin, who is case-studied in section 7.1.

Maths is boring a lot of the time (Nicola<sub>MetaphorYear10</sub>).

Unlike their discussions about the difficulty of mathematics (section 5.2.3), students invariably linked their boredom with negative feelings. Ostensibly, boredom with mathematics could be seen as both a student's view about the subject (Maths is boring) and a feeling (I feel bored). Certainly, the students described the feelings that resulted in boredom as tiredness, lethargy, and sometimes, anger and frustration.

I feel negative emotions in maths when I am given boring stuff to do (almost all the time) (Peter<sub>AutobiographyYear10</sub>).

Boring makes me tired (Philip<sub>EndofYear10</sub>).

More than this, boredom formed an important part of their view about mathematics as a unique subject.

[Maths] is boring. That's what makes it unique (Paul<sub>EndofYear10</sub>).

Hannula (2002) explained that when students were asked to reflect on mathematics, their first reaction was usually emotional and based on associations with their previous mathematical experiences. Indeed, the students in this research linked school mathematics immediately and directly to boredom or the subject's difficulty. Thus, boredom has been included as forming part of the students' view of mathematics.

Given the prominence of boredom in the students' stories, I decided to further explore the concept by introducing the issue of boredom as part of a class discussion. The students were asked to define the concept in a written response. The level of boredom students' experienced was conditional on *what* they were doing and *how* they were doing the activity.

[You are bored when] you are not interested in the thing that's boring and it's not exciting or fun! (Joanna<sub>EndofYear10</sub>).

It depends on what we're doing. Certain [subjects] in maths are like boring blah and some ones are like fun and happy (Jennifer<sub>InterviewYear10</sub>).

Mathletics. It was fun. They made maths fun instead of boring in a classroom [Naomi: Did you learn anything?] Uhh ... not really (Bridget<sub>InterviewYear10</sub>).

The students frequent experiences of boredom led to an overall view of mathematics as a boring subject. For the majority of these students, mathematics was not exciting, fun or interesting, and they perceived it as a subject full of tasks that were endless and repetitive. This was particularly true for the students who felt mathematics was not an important subject.

I pretty much find it boring because I don't really see I'll be using it a lot, so ... (Paul<sub>EndofYear10</sub>).

Like the students in Boaler's (2002b) research, the students did not blame their boredom on the nature of mathematics. They had enjoyed mathematics in primary school. The students usually connected their boredom to the invariable routines of school mathematics.

Notes, textbook blah blah blah (Debbie<sub>GroupInterviewYear11</sub>).

If we say we're bored, the teachers go ... well you've got work to do. You shouldn't be bored. It's [the work] that's ... making me bored! (Amanda<sub>InterviewYear10</sub>).

Alasdair: The worst thing about maths is the boredom. Doing textbook work, doing stuff on the whiteboard.

Katrina: Yeah, copying, answering basic questions ... umm.

Alasdair: Copying down irrelevant notes.

Katrina: Even copying down relevant notes is boring. The teacher comes into the room said, right here's a new topic, here write these notes and turn to page 37 and do 1,3,5,7.

Alasdair: (Alasdair sounds excited) That's the one! That's exactly it! That hit the nail right on the head. That is maths (AlasdairKatrina<sub>GroupInterviewYear11</sub>).

As described in the nature of mathematics above, because of the cumulative nature of mathematics – the way new content was taught on top of content from previous years – compared to other subjects, the students spent a large proportion of their time revising content from previous years. Despite talking about the need to practise the mathematical concepts (section 5.2.3), the students also became bored with the repetition of this content.

[The problem with maths] is mainly the repetitiveness ... it's I've done it once. I've done it a million times (Amanda<sub>GroupInterviewYear11</sub>).

Peter: I get bored when repetition gets too much ... and they try and grind it into your skulls

Jason: I hate repetition

Peter: I don't want to learn the stuff I learnt in Year 9 ... every single year! Measurement is measurement! It's a millimetre. How many times do they have to tell you that? (PeterJason<sub>GroupInterviewYear11</sub>).

The students also sometimes linked boredom with the difficulty of the subjects, describing themselves as bored when the mathematics was too easy.

[Its boring] when you understand it completely and you just want to get past it because it's really easy but you have to go through all the tediousness (Peter<sub>GroupInterviewYear11</sub>).

Other students described themselves as bored because they found mathematics difficult.

Sometimes it gets boring when you find it hard to understand and work out. It gets exciting when you know what you're doing and it's fun to work with (Dawn<sub>InterviewYear10</sub>).

I think that maths is quite boring. I know I need it but I think it's boring. It's all right at times when it's not too difficult but on the whole it's pretty boring. Especially when it's difficult ... Most of the time it's quite challenging (Susan<sub>MetaphorYear10</sub>).

Boredom is under-researched in mathematics education, despite students' frequent citing boredom when asked their views on mathematics (e.g., Ruffell, Mason, & Allen, 1998). In the general education field, research into boredom is limited despite adolescents' frequently reporting to be bored and boredom often being given as a reason for school dropout (Larson

& Richards, 1991). Larson and Richards's (1991) research, which studied boredom across the daily lives of 392 fifth to ninth grades in Chicago, described three different models of boredom. They have similarities to how boredom is experienced in this research. The students associated their boredom with habitualised, repetitive tasks (under-stimulation). The students perceived they were in a situation over which they had little control and felt compelled to spend mental effort on difficult and abstract material, which often ended in frustration (forced-effect). Furthermore, their boredom was perhaps, in part, a defence mechanism. The students reframed a situation where they did not want to do something to a socially accepted response to work that lacked meaning and purpose (social construction). As Boaler (2002b) suggested, the students were perhaps exercising their own style of control over school mathematics. In this sense, students' discussions of boredom were both a form of communication and a social role. There was some evidence that students talked about boredom because they experienced difficulty, but there is little evidence that they used boredom as an adolescent excuse for their lack of engagement.

The mathematics curriculum (Ministry of Education, 1992) explicitly require teachers to use a variety of learning experiences, to continually re-evaluate the use of text-books, and to consider experimentations rather than the memorisation of rules. There was some indication that Mrs Brown wanted to include more variety in her lessons but she did not have the confidence to do so because of her need to control the class and her perceived lack of conceptual knowledge of the mathematics. By using the textbook Mrs Brown protected her authority and reduced likely challenges from the students but this also meant opportunities were lost for engaging students in mathematics (Ewing, 2004).

I'm not confident with this class who have maths ability that is better than mine because I feel it could put me in the situation I don't like. They can lose respect for me because I don't know as much as them and I can't help them so I'm not prepared to do anything other than do exercises on the board or give them work to do from the text book or worksheets. I'm not. Huge risk. I'm more prepared to do that with my [juniors] because I know that I've got a fat gap between their knowledge and my knowledge. It's not just the maths. It's the management of the class. If you had a whole class of students with their head down, I think I'd be more prepared to do [other things] (MrsBrown<sub>InterviewYear10</sub>).

The routines the students described are not unusual. They are similar to the classroom routines described in research both overseas and in New Zealand (e.g., Beswick et al., 2006; Young-

Loveridge et al., 2006). Perhaps the teachers taught in this way because that is the way they had been taught mathematics or the way they perceived mathematics had traditionally been taught in that school. The mathematics teachers are learning to be participants in their own mathematics teaching community. The norms and routines of the classroom are a product, among a number of other factors, of the teacher and students' views of mathematics teaching (Beswick, 2005b, 2007; Beswick et al., 2006), and as the teachers and students participated in the mathematics classroom, they are both contributing and maintaining these factors.

### **5.2.5 Students' views of mathematics and their engagement**

The students associated their views of mathematics with their engagement in the subject in complex ways. They generally discussed their engagement as an outcome of their views of mathematics. Only occasionally was there a suggestion that the students perceived their engagement to influence their views about mathematics. Mark's participation in mathematics changed his view of a topic's difficulty, for example.

I always think [topics] are going to be a lot worse than they are like they say they're going to be hard and then they're not when you actually do them (Mark<sub>InterviewYear10</sub>).

Even though there was little evidence that students' engagement influenced their views about mathematics, this influence perhaps exists more strongly than the students' stories imply. As Boaler and Greeno (2000) explain, students learn how to be mathematics students through participation. Through engaging in the mathematics, the students contributed to and perpetuated the routines of the mathematics classroom and the common views of school mathematics.

The students associated their engagement in a specific problem with their mathematical knowledge. As discussed in section 5.2.1, the students' perception of knowledge was both their knowledge of the mathematical content and the mathematical rules. The students did not have experience in constructing these procedures for themselves and this meant to do the mathematics, the students needed to know the procedure.

You've got to know maths to be able to do it (Debbie<sub>GroupInterviewYear11</sub>).

In section 5.1, students viewed engagement to be necessary for learning to take place. Indeed, they viewed engagement in the subject to be necessary because of the nature and difficulty of the subject.

Umm, I suppose I actually try in maths. Well, I do try in my other classes but more in maths ... maths is kind of like weird. Other classes you can write it down like speaking but maths you've got to actually try to get the right answer Yeah ... like you ... the other [subjects] are just different ... if you get the right answer you're on the right track you can do all the rest of the questions. It's just kind of like the start that you need to do (Cheryl<sub>InterviewYear10</sub>).

Yair (2000) suggested the cumulative nature of mathematics required students to engage more than in subjects such as English and the social sciences. In his view, inattention in other subjects only had a minor detrimental effect compared to inattention in mathematics. In the current research, the students also believed that the nature of mathematics and the difficulty of the subject, when compared to other subjects, made it potentially very difficult for students to catch up when they missed work through disengagement.

There's so much in maths ... if I get left behind in maths ... it would probably be the worst subject to try and catch up than any of my other ones. There's just a lot to it. There's a lot more (Debbie<sub>GroupInterviewYear11</sub>).

This difficulty in catching up with missed work had implications when a student was absent. All students were absent from the class at least once during the research period because they had lives external to mathematics. There were a variety of reasons given for absences, examples of which are shown below.

Ballet, sports injury, music, illness, school production, depression, completing previous class's activity, discipline issues, appointments, sleeping in, sports trips, subject trips, family holidays, duck hunting, community and charity events, transport problems, family issues, counselling

When a student was absent from the mathematics lesson, they talked about missing the learning of new content, and opportunities to consolidate previously taught content. They also talked about experiencing difficulty because of the lack of continuity, especially when an

activity lasted for more than one lesson. This led to gaps in their knowledge and understanding, further absences, confusion, and lowered achievement in assessments.

Because I was away for a week ... I completely forgot everything and that's why I [failed the assessment] (Tracey<sub>InterviewYear10</sub>).

[I don't like] the topic we're doing now ... The one today I hadn't done because we needed the measurements from yesterday because I was away. I felt ... oh God (Nicola<sub>InterviewYear10</sub>).

I was sick when they did the cosine rule for sides ... in the textbook it's written differently. [In class] Mr Carter decided that we would do it how it's written in the assessment and not how it's written in the textbook. So then it was really confusing using that textbook (Katrina<sub>GroupInterviewYear11</sub>).

Bridget: We just asked [the teacher] to stay behind to help us ... the sine rule and cosine rule. Because we'd been away for stage challenge and stuff we didn't understand half of it ... and then she moved on. We'd just got the stuff we'd moved on to and she moved on again. Aargh.

Joanna: It was so hard (BridgetJoanna<sub>GroupInterviewYear11</sub>).

Some of the students were absent from class more than others. Paul, missed 41 periods of mathematics during Year 10 and 20 periods (the maximum allowed) in Year 11. Saskia missed over 30 periods of mathematics over two years.

Yeah. [I do miss a few classes]. [It is] not always [hard to catch up], but sometimes it can be if I'm really behind (Paul<sub>InterviewYear10</sub>).

[Saskia is] absent lots, so has big gaps in what we supposedly have been doing, but has shown little initiative to fill these gaps (MrsWhite<sub>Year11</sub>).

When you go back to school, you're behind in everything so you get absent more and more and there's just so much ... augh (Saskia<sub>InterviewYear11</sub>).

Generally, the students viewed engagement in the mathematics to be necessary because of the problems they experienced when they disengaged or were absent, and their view of

mathematics as a difficult and content-rich subject. Like the students in Sullivan et al.'s (2006) research, they appreciated the importance of engagement for mathematical success.

Other aspects of the students' views about mathematics were somewhat contradictory to this. Given many students were ambivalent about the subject's importance (section 5.2.2), there were only rare associations found between their perceptions of the importance of mathematics and their engagement.

I am aware that I need to try my hardest. I think I am more attentive than in other classes. I know we need to know this (Sean<sub>InterviewYear10</sub>).

More commonly, the students' view of their role in mathematical learning was that they were *required* by their teachers, the school, and their parents to engage in the activities of the classroom. Indeed, through their stories of the importance of mathematics and their expectations of engagement and achievement, parents influenced their child's perception of the need to engage both outside and inside the mathematics classroom.

[My parents] think especially this term I should be doing more ... this term ... I don't try as hard and I've hardly done anything ... when I tell Mum that, she thinks I should be making more effort and trying to get more work in (Jill<sub>GroupInterviewYear10</sub>).

At home, many students asked for help from their parents. Ann, however, did not ask for help at home. Ann felt unable to ask her mother for help because she was aware that her mother felt uncomfortable in helping her. Anthony and Walshaw (2007) describe how parents who had bad experiences of doing mathematics themselves sometimes do not have the confidence or knowledge to help their children. Ann's feelings about mathematics and her view of her ability in the subject reflect her mothers' views.

Maths has never been Ann's strongest subject but she tries hard and gets her work done ... not her favourite subject. [I'm] no good at maths ... I missed maths class as much as I could, would go to sickbay or did something else around the school with my friend, who was no good at school work too. Found maths very boring, couldn't understand much (AnnMum<sub>QuestionnaireYear10</sub>).

I find [maths] quite hard, like depressing sort of ... yeah, maths is my worst subject (Ann<sub>InterviewYear10</sub>).

Mum was never very good at maths. [At home] I try and work it out by myself. I think she tries to help but it worries her ... it makes her feel kind of bad (Ann<sub>InterviewYear10</sub>).

Nardi and Steward (2003) also connected students' engagement in mathematics with the importance others in the community placed on mathematics and engagement. The students in their research engaged in mathematics mostly out of sense of what Nardi and Steward (2003) called a "professional obligation" for future employment, and because of fear of school and parental sanctions. In this research, the word "obligation" seems fitting. The students generally felt "obliged" to engage in the activities of the mathematics classroom. Further counteracting the students' perceptions of their need to engage in the mathematics, the students' strongly associated their boredom with their engagement. The students described their boredom as affecting their engagement in terms of the amount of work they did, the depth to which they did the work, their level of perseverance and the time they spent socialising. The students also made associations between their engagement and their level of interest in mathematics. Mathematics compared unfavourably with other subjects in terms of this interest.

When you're bored you just sit there going arrrrr (Amanda makes a quiet tired sound) and just stare at the roof (Amanda<sub>GroupInterviewYear11</sub>).

Maths is rather boring. Boring is when you ... can't be bothered ... and not want to learn (Philip<sub>EndofYear10</sub>).

If I'm bored ... I often don't get as much work done. ... Yesterday I guess I didn't work to the depth required that much because I was ... bored with it (Jason<sub>InterviewYear10</sub>).

[If it is boring] I don't attempt some of the work (Nicola<sub>InterviewYear10</sub>).

I kind of talk a little bit more [in maths] because I kind of get bored. I do work pretty well in most classes. I still do work in maths, but just not as well (Paul<sub>InterviewYear10</sub>).

I work hard in other subjects. I talk the most in maths ... I can try and work in maths, but it just doesn't do anything for me so I just can't be bothered. Other subjects like Art, I'm just like quiet the whole thing because I'm like ... doing it (Tracey<sub>InterviewYear10</sub>).

Probably in maths I don't really pay attention that much ... not compared to other subjects that I am interested in (Nicola<sub>InterviewYear10</sub>).

Lange (2008a) explored aspects of learning difficulties in mathematics from the students' point of view. Students in his research "begin to be bored" or skip mathematics when they found it challenging, and "you begin to do things you're not supposed to". In both Lange's research and the current research students become defensive when they found the mathematics difficult. Students who have an instrumental approach (Schoenfeld, 1985) expect to be able to complete problems quickly. When they cannot, they describe themselves as getting bored, thus using this as a socially acceptable adolescent defense mechanism. Perhaps too, they are simply bored because, lacking skills in different strategies, they are unable to engage in the mathematics and have nothing else to do. Like Bridget, they perhaps disengaged in mathematics because of the need for more than superficial level of thinking.

I talk more in maths ... I just can't be bothered doing it. It's easier to talk than making my brain hurt (Bridget<sub>InterviewYear10</sub>).

Students' views of mathematics were therefore associated with their engagement in complex ways. They talked about the importance of engaging in mathematics because they were obliged to, because of parental and school pressure, and because of their perceptions of the subjects' difficulty and nature. On the other hand, they also talked about their disengagement in the subject because of the subject's difficulty and the boredom they experienced.

### 5.3 Conclusion

This chapter has described school mathematics from the students' perspective. Their relationships with mathematics were different from their relationships with their other school subjects. In their view, mathematics was a unique subject because of being exact, logical and only having one correct answer, the invariable routines, the amount of content knowledge required, the number of rules that needed to be memorised, the fewer opportunities for group work, and the proportion of the lesson spent on solving textbook problems individually. The students perceived mathematics to be more important, more difficult, and more boring than their other subjects. Anthony and Walshaw (2007) stated that many of the problems associated with learning mathematics have little resemblance to those encountered in other

school subjects. Indeed, in this research, the students' view of mathematics as a unique subject was associated with their engagement.

Introduced in this chapter is how the students talked about aspects of their engagement as an outcome of their relationship with mathematics, rather than, or as well as, their learning or achievement. The students' somewhat contradictory views of mathematics made them vulnerable to disengagement. On the one hand, they talked about the necessity of doing mathematics for success and the difficulties they experienced when they disengaged. Indeed, the students felt obligated to engage in the mathematics. On the other hand, they were ambivalent about the importance of the subject and talked about their disengagement because of the level of boredom they experienced with the subject. They expected to receive the knowledge passively without thinking at a more than a superficial level. When they were forced to think they often disengaged. These contradictions and resulting tensions meant that there was fluidity in the students' stories about the ways they engaged in the mathematics.

Students' views about the subject form part of their relationship with mathematics. Other aspects of these relationships and how these are associated with students' engagement in mathematical tasks are explored throughout the thesis. Their views of mathematics had important implications, not only for their engagement in the subject, but also for their feelings about mathematics compared to other subjects, and their decisions to participate in mathematics in the future. In the next chapter, these aspects, and the association between students' feelings and identities related to mathematics are explored.



## CHAPTER SIX: Feelings and Identities

This chapter further develops the elements of the students' complex and dynamic relationships with mathematics. Chapter Five introduced how the students described their engagement in the subject and explored their views of mathematics. As discussed in section 5.2.3, when analysing students' views of mathematics, attempts were made to understand them without making assumptions about whether they were positive or negative. Students' discussions of boredom were an exception to this. Students' feelings about mathematics are examined in this chapter and discussed in relation to students' mathematical identities. Students' changing relationships with mathematics as they experienced mathematics are then discussed.

### 6.1 Students' feelings about school mathematics

This section explores the students' feelings about and during mathematics. In the literature reviewed in Chapter Two, affect was conceptualised as variously including students' beliefs, attitudes, feelings, and emotions (section 2.2), and was considered to form an important part of students' mathematical core (section 2.3). In this research, it was difficult to find an example of a conversation about mathematics in which a student did not refer in some way to aspects of affect. Indeed, students' feelings about mathematics were often given as their initial response in the interview, irrespective of what the first interview question was. Students used the term 'feelings' to describe their attitude towards the subject of mathematics and their experiences of feelings and emotions.

The students talked about experiencing neutral, positive, or negative feelings. As can be seen by the examples in Figure 6.1 later in this section, and in other examples throughout Chapters Six and Seven, the students in this research used many adjectives to describe their feelings, usually after the words "I feel ..." or "I felt ...".

Angry, annoyed, anxious, bored, confused, depressed, disappointed, excited, freaked, frustrated, glad, good, happy, helpless, insane, interested, intimidated, irritated, joyous, motivated, nervous, neutral, okay, panicked, proud, relieved, restless, sad, sick of, sleepy, smart, stink, strange, stressed, tired, uncomfortable, unenthusiastic, upset, worried.

The feelings students described had a range of intensities. Sometimes the intensity of their feelings could be interpreted from what they said, though it is acknowledged this interpretation was subjective. Paul, for example, when he was interviewed in Year 10, was okay with the subject of mathematics but did not really look forward to it. This was interpreted as a neutral though slightly negative response. Tracey, on the other hand, talked about hating the subject of mathematics, which was considered to be an intensely negative reaction. Occasionally, in the group interviews in Year 11, the students were asked to rate the intensity of their feelings. Level one described a feeling of low intensity, and level three described a feeling of high intensity.

There are really intense things that happen in maths. I call them three feelings. A three feeling you'd probably go home and cry about it (Ruth<sub>GroupInterviewYear11</sub>).

Jason: I've never got a [grade of] Not Achieved. Not Achieved would really upset me, but that's never happened. Lately my marks have just been Achieved and I'm not upset but I'm a little disappointed ... a one or a two feeling.

Peter: When I'm bored it's really bad.

Jason: No, [boredom is] not intense for me (PeterJason<sub>GroupInterviewYear11</sub>).

During the research process, the students began to distinguish between two types of feelings. Connor, during a class discussion, labelled these 'macro-feelings' and 'micro-feelings', using terminology he had learnt in economics. With my support, the other students adopted this terminology and the research has been reported using these terms. *Macro-feelings* are defined as the students' overall feelings about the subject of mathematics, including general like or dislike. *Micro-feelings* are the relatively transitory emotions the students' experienced when they engaged in a mathematical task.

Students' mathematical journeys were a complex mix of stable and transitory elements. Distinguishing between macro and micro-feelings when analysing data was a useful way to consider both how students' feelings about mathematics impacted their learning and engagement in the mathematical classroom, and how feelings impacted students' relationships with the subject over time. Exploring the interaction between macro and micro-feelings about mathematics enabled the development of students' mathematical journeys to be better understood. These interactions are explored in sections 6.1.1 and 6.1.2.

	MACRO-FEELINGS	MICRO-FEELINGS
POSITIVE	I feel happy and good about maths. It is my favourite subject (Connor <sub>Intermediate Year 10</sub> ).	I feel happy and excited when I pass something I thought I might fail – Level of intensity Three (Ann <sub>Composite Year 11</sub> ).
	Doing maths just feels normal. Sort of like naturally there. I really enjoy doing maths. I always have. If I could think in numbers I think that I would (Ben <sub>High Level Year 10</sub> ).	I had a good experience the day we started Algebra last year. I got it instantly. I just got it straight away (Corrina <sub>Intermediate Year 10</sub> ).
NEUTRAL	It's fine. I don't mind maths. [I have] average [feelings] sort of. I don't hate it and I don't love it. I like it more than hate it so it's probably just above that (Jason <sub>Intermediate Year 10</sub> ).	I feel good when I get credits in maths because I need them to pass NCEA – Level of intensity Two (Mark <sub>Composite Year 11</sub> ).
	It's just maths ... [I feel] pretty middle of the road. Don't really care that much ... it's just there (Lola <sub>Intermediate Year 10</sub> ).	I like when I finish something before other people. It is good to accomplish something (Jason <sub>Composite Year 11</sub> ).
	[Maths is] OK, but not something that I look forward to (Paul <sub>Intermediate Year 10</sub> ).	
NEGATIVE	For me maths is most like a storm. A storm that comes once every day during the school week for an hour and when it leaves it doesn't come back until the next day. The storm is dull, uninteresting and horrible. It makes me feel tired, bored and when it leaves I feel happy again (Jill <sub>High Level Year 10</sub> ).	I feel annoyed when I get a relieving teacher that doesn't know maths – Level One intensity (Philip <sub>Composite Year 11</sub> ).
	If maths was a food it would be silver beet and silver beet is disgusting. If maths was a colour it would be brown because it's dull. If maths was a hairstyle it would be a bowl cut because it's an ugly hairstyle. If maths was an animal it would be a cow because cows smell. If maths was an object it would be a blank bit of paper because it's plain and not exciting. If maths was music it would be classical because classical is boring. If maths was a TV programme it would be Coronation Street because Coronation St is boring (Susanne <sub>High Level Year 10</sub> ).	I felt annoyed when I got Achieved on a maths test and not Merit because I know I can get better – Level Two intensity (Paul <sub>Composite Year 11</sub> ).
		I feel stupid. Annoyed. Like 'duh' when getting a test back where I've done something stupid – Level Two intensity (Amanda <sub>Composite Year 11</sub> ).
	LOL, I always do [feel negative]. I hate maths! (Tracey <sub>High Level Year 10</sub> ).	I feel really angry at myself when I can't work out a problem – Level Three intensity (Jill <sub>Composite Year 11</sub> ).
	[I remember] crying because I couldn't do my multiplication. I was getting really angry and upset because everyone else was doing it and I was the only one confused (Maira <sub>Composite Year 10</sub> ).	

FIGURE 6.1 Examples of macro-feelings and micro-feelings

Figure 6.1, above, gives examples of students' macro and micro-feelings. These examples have been subjectively placed on a continuum of positive to negative, and it is acknowledged that each placing is just one of several possible interpretations of intensity. Note that LOL in Tracey's comment means Laugh Out Loud, an acronym commonly used in cell-phone sms messaging at the time when these data was used.

Macro and micro-feelings may be viewed as similar to McLeod's (1992) conceptualisation of attitude and emotions, described in section 2.2. In his conceptualisation, attitude was considered to be stable compared to hot and transitory emotions. Indeed, the students' macro-feelings in this research were relatively stable compared to their micro-feelings, though they did change over their journeys, as shown in section 6.1.1. McLeod (1992) also talked about an attitude being a moderate affective response and referred to emotions as intense or hot. In contradiction to this, the students in this research described a full range of intensities of macro and micro-feelings.

The students' labelling of macro and micro-feelings can also be compared to state and trait emotions. As described in section 2.3, state emotions are seen as the momentary occurrences of emotions within a given situation, and trait emotions are habitual recurring emotions typically experienced by an individual in relation to an activity (Pekrun, 2006). In other words, like micro-feelings, state emotions are situational-specific and macro-feelings and trait emotions are less context specific. However, emotions tend to be discussed in terms of the more intense reactions to mathematics, and macro-feelings occur and operate at a range of intensities.

Macro and micro-feelings are also similar to DeBellis and Goldin's (2006) conceptualisation of global and local affect, described in section 2.3. A student's local affect, which could be considered to be similar to a micro-feeling, is their changing states of emotional feelings during mathematical activity. Global affect is a longer-term affective structure, similar to macro-feelings. Unlike McLeod's (1992) ideas of attitudes and emotions, DeBellis and Goldin's (2006) conceptualisation does incorporate a range of intensities of affective responses. Their research used observations within clinical task-based interviews with children to infer the way children internally represent affect. Although different to this research in terms of the methodology used, DeBellis and Goldin's (2006) research is useful in understanding the interactions between macro and micro-feelings and examining students'

pathways of engagement – the pathways they usually took to solve a mathematical task (section 5.1).

The following sections further define macro and micro-feelings and the interaction between them. The associations the students made between their feelings and other elements of their relationships with mathematics are also explored.

### 6.1.1 Macro-feelings

This section explores associations the students' made between their macro-feelings, their engagement in mathematics, and continued participation in the subject. Isolating students' macro-feelings enabled their mathematical journeys to be described in greater detail. This section also examines trends in students' macro-feelings during their journeys, and explores some of the reasons students gave to account for changes in their overall feelings about the subject of mathematics.

All thirty-one of the students directly associated their macro-feelings with their engagement in the mathematics or their mathematical learning. When they felt positively about mathematics, they engaged more in the subject. When they did not feel good about the subject overall, they did not learn or engage as well.

At the start of the year I wasn't happy in that class and didn't work

(Moir<sub>InterviewYear10</sub>).

I love maths. It makes me think. I like thinking. I spend a lot of time doing maths

(Colin<sub>GroupInterviewYear11</sub>).

Probably in maths I don't really pay attention that much ... not compared to art and stuff because I enjoy those subjects (Nicola<sub>InterviewYear10</sub>).

Students' macro-feelings contributed to the context within which they engaged in a specific mathematical activity. When a student had negative macro-feelings for the subject of mathematics, they were more likely to have negative micro-feelings in each mathematical situation. A student with an overall feeling of worry about their progress in mathematics, for example, was more likely to be anxious when they did not understand something in class.

When they “felt bad” about mathematics overall, they were more likely to feel negatively about a task.

I feel bad about maths so I just look at the question and think uugh

(Amanda<sub>GroupInterviewYear11</sub>).

This was not always the case.

I don't like maths ... but ... I don't like the thought of maths ... but when I'm actually doing maths it's okay. I feel okay (Joanna<sub>GroupInterview Year11</sub>).

Joanna felt unhappy about the thought of mathematics, but when she engaged in the mathematics, she did not experience these feelings.

All of those students who liked mathematics also perceived they were good at it.

I still like mathematics but that's because I'm quite good at it (Ben<sub>InterviewYear10</sub>).

However, the reverse was not the case. Not all students who felt they were good at mathematics liked the subject. Peter and Jason disliked mathematics but felt confident in their ability.

I am good at maths. I don't like learning maths (Peter<sub>GroupInterviewYear11</sub>).

I don't like enjoy [maths] the most, but I can do [it] (Jason<sub>InterviewYear10</sub>).

A student's macro-feelings about mathematics contributed to their decision to continue to enrol in the subject when the subject no longer became compulsory. The students' intentions of continuing to participate in mathematics were a negotiation between their macro-feelings about the subject and other aspects of their relationship with mathematics, such as their view of mathematics (section 5.2). The continued participation of students in the subject of mathematics, for example, was vulnerable for those who were ambivalent about the importance of mathematics as a subject. The following quotes are representative examples of students' answers to the question “Would you take mathematics after Year 11?” which they responded to at the beginning of Year 10. It should be noted that two years after answering

this question, Frank, Bridget and Jennifer chose not to continue with mathematics in Year 12, when mathematics was no longer compulsory (Students<sub>SubjectChoiceYear12</sub>).

Yes, because it's one of those subjects I'm relatively good at and I enjoy (Ben<sub>AutobiographyYear10</sub>).

Yes, even though I don't like maths very much, I'd still take it because it plays a big part in whatever career I choose (Nicola<sub>AutobiographyYear10</sub>).

Yes, because you need it for jobs, but I would drop it later (Mark<sub>AutobiographyYear10</sub>).

No, I wouldn't [take maths], because I have to think in maths ... I don't like it (Frank<sub>AutobiographyYear10</sub>).

No, because I don't really like maths (Bridget<sub>AutobiographyYear10</sub>).

No, I'd rather choose a different subject because I like other subjects better (Jennifer<sub>AutobiographyYear10</sub>).

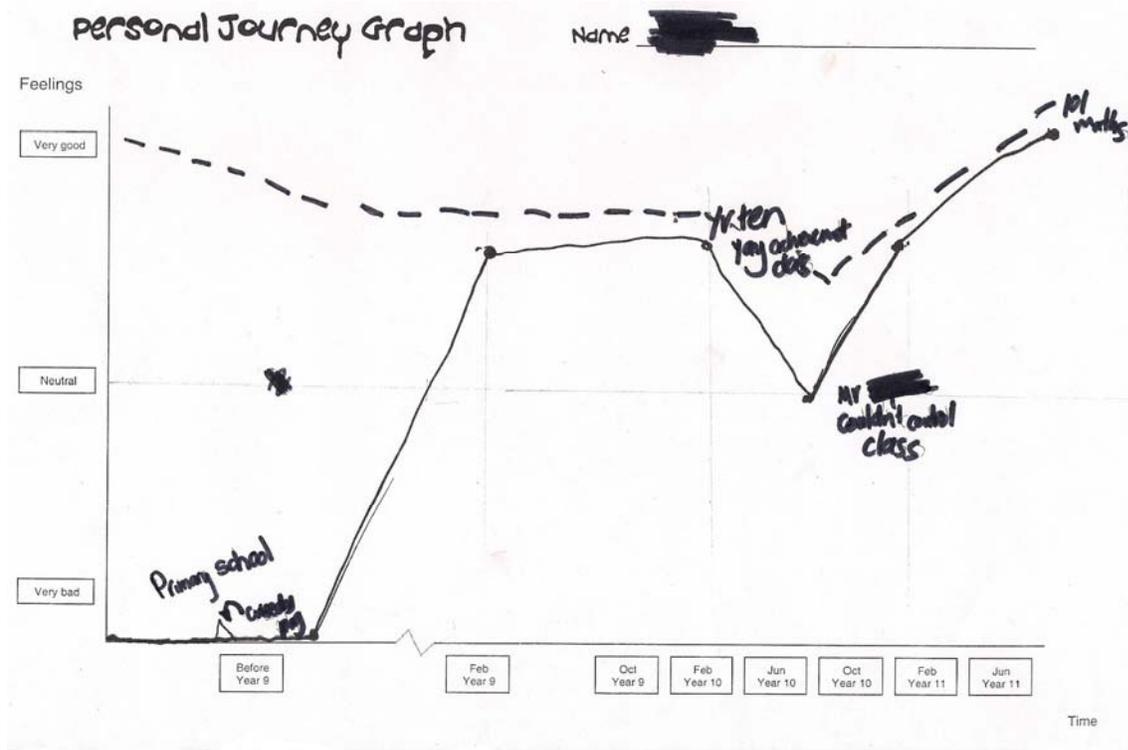
There was evidence that students' macro-feelings changed over their mathematical journeys. The students reflected on these feelings when they drew personal journey graphs in Year 11 (section 4.4.6). A few of the students' personal journey graphs swung from positive to negative and back again and did not follow any general trend. Furthermore, the students drew them as continuous graphs. If a student, for example, was positive throughout their journey except for one incident on one day, this spike was often joined to previous data, sometimes suggesting that students feelings began to get, for example, more negative before the incident happened. All of these factors have been taken into account when reflecting on the results. Four of the students had become more positive about the subject of mathematics over time. Sean's personal journey graph is provided in Figure 6.2. The axes labels are difficult to read. On the vertical axis he positioned their feelings against the labels 'Very Good', 'Neutral', and 'Very Bad'. On the horizontal axis is time. The comments written on Sean's personal journey graph are "Primary school", "Greedy Pig", "Year 10. Yay achievement class", "Mr Murray couldn't control class", and "101 Maths". Sean described experiencing great difficulty in mathematics at primary school. After receiving specialist tutoring, he began to enjoy mathematics more, with the exception of one time period, when his feelings went back to neutral. Greedy Pig is the name of a mathematical game which Sean remembers enjoying.

The dashed line is Sean's feelings about English, which dipped around examination time in Year 10.

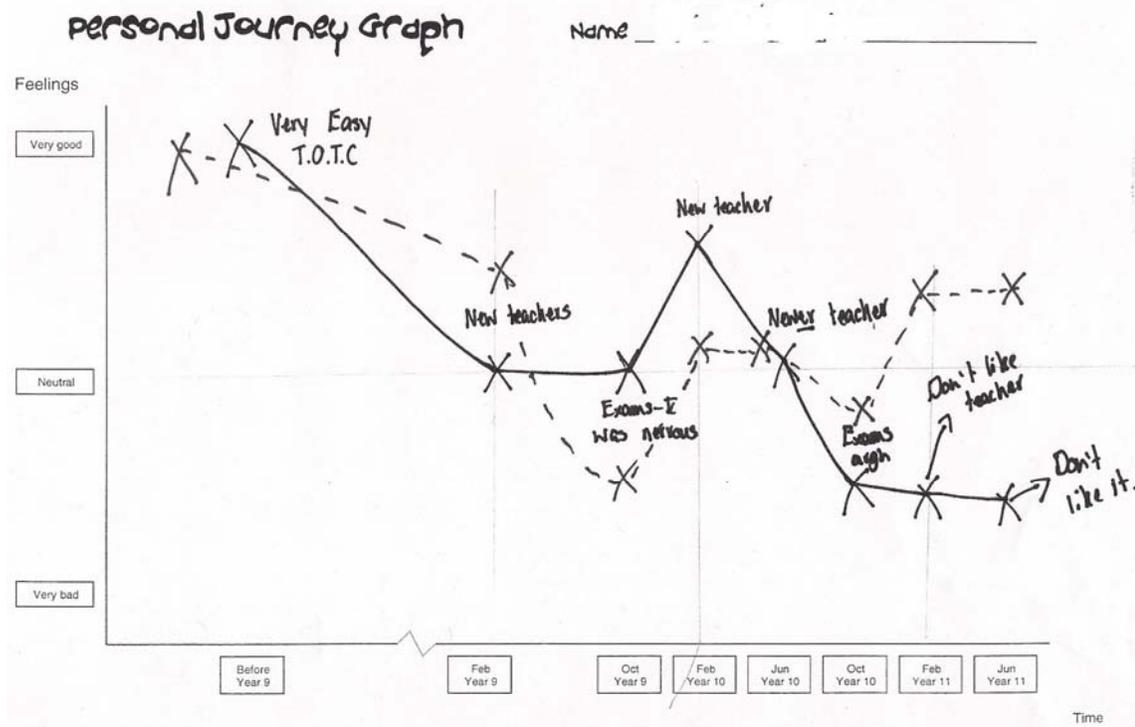
The majority of the students, however, became slowly more negative about the subject of mathematics over their mathematical journeys.

As the years go by I slowly dislike it more (Nicola<sub>FurtherResponseYear11</sub>).

The personal journey graphs of 17 students followed a general negative trend, as shown in Joanna's personal journey graph in figure 6.3, below. Joanna's English graph, shown by the dotted line, is somewhat similar to her mathematics graph because her feelings in English were also teacher and assessment dependent.



**FIGURE 6.2** Sean's personal journey graph showing his feelings about Mathematics (continuous) and English (dashed)



**FIGURE 6.3** Joanna's personal journey graph showing her feelings about Mathematics (continuous) and English (dashed)

Prior to being in Year 9, the students charted that they felt positively about mathematics 64 percent of the time (section 4.4.6 for details on how this percentage was calculated). In the following years, the students felt positively about mathematics for only around half of the year. These percentages do not capture the intensity of students' negative feelings. The students often represented their negative feelings as intense and drew them well below the neutral line, although positive feelings were often depicted by the students to be of relatively weak intensity and charted on the personal journey graphs just above the neutral line.

Negative feelings are more intense than positive ones ... yeah, but I'm a negative person (Saskia<sub>Interview2007</sub>).

Similar to findings in other research (McLeod, 1994), the majority of students in this research generally disliked mathematics. When the students were in Year 10 and 11, twenty four out of thirty-one students consistently viewed mathematics neutrally or negatively (Students<sub>AutobiographyYear10Year11</sub>). Moira, for example, disliked mathematics in Year 10 and continued to dislike the subject in Year 11 (Moira<sub>AutobiographyYear10Year11</sub>). Only seven students consistently stated in their autobiographies that they liked the subject of mathematics and enjoyed participating in it.

Chapter Five concluded that the students viewed mathematics to be a unique school subject in terms of its nature, importance, difficulty, and the boredom it produced. The students also viewed mathematics to be a unique subject *because* of their level of dislike and the proportion of people who disliked it.

Maths is different from other subjects because so many people don't like it  
(Amanda<sub>GroupInterviewYear11</sub>).

These results are slightly different from New Zealand research of younger students. New Zealand's National Education Monitoring Project (NEMP) aims to get broad four-yearly picture of the achievement, attitude and motivation of school students at Year 4 and Year 8 (Educational Assessment Research Unit, 2011). The results from the 2009 mathematics survey revealed that mathematics was a popular subject among students at Year 4, ranking second among 14 subjects. Year 8 students ranked mathematics as their third most popular subject, though mathematics scored well behind physical education and sport, and technology. What is interesting is that although two-thirds of year 4 students were positive about learning and doing mathematics, as they got older, only one third of Year 8 students were – 32% more Year 8 than Year 4 students were negative about doing mathematics in their own time. These results may be indicative of students becoming more cautious about expressing high enthusiasm and self-confidence over the four additional years of schooling (Educational Assessment Research Unit, 2011), but there is some consistency with the students in this research in this change.

Many of the students felt that the transition from primary to secondary mathematics in Year 9 was particularly difficult and they were still getting used to the change. As the students' perceived the mathematics to get more difficult and the classroom routines became more entrenched, the majority of students began to find it less enjoyable.

It was pretty easy, and fun back [in primary school] ... just enjoyable to do ... like ... not how it is now ... like ... kind of hard ... it's just bookwork and stuff now  
(Paul<sub>InterviewYear10</sub>).

[Primary school] was better than [secondary] school. [Mathematics] got harder and I didn't like it as much ... Probably last year was my worst maths experience ... It was just like harder last year than any other year ... I guess [maths] is sort of negative

because it's too fancy. It makes me feel negative about learning ... It's one of those complicated subjects that I hate pretty much (Bridget<sub>InterviewYear10</sub>).

Students' macro-feelings interacted with other elements of their relationships with mathematics. The students' attributed their level of dislike to their developing views of mathematics. Generally, the students had an instrumental view of mathematics (section 5.2.1). Mathematics was a collection of facts and procedures that needed to be remembered and performed in isolation. This, with their view of the routines of the mathematics classroom, was related to their perception of mathematics as a boring and difficult subject. This result is consistent with other research. Zan and Di Martino's (2007) research, described in section 2.2, indicated, for example, that students with an instrumental view of mathematics, generally disliked mathematics.

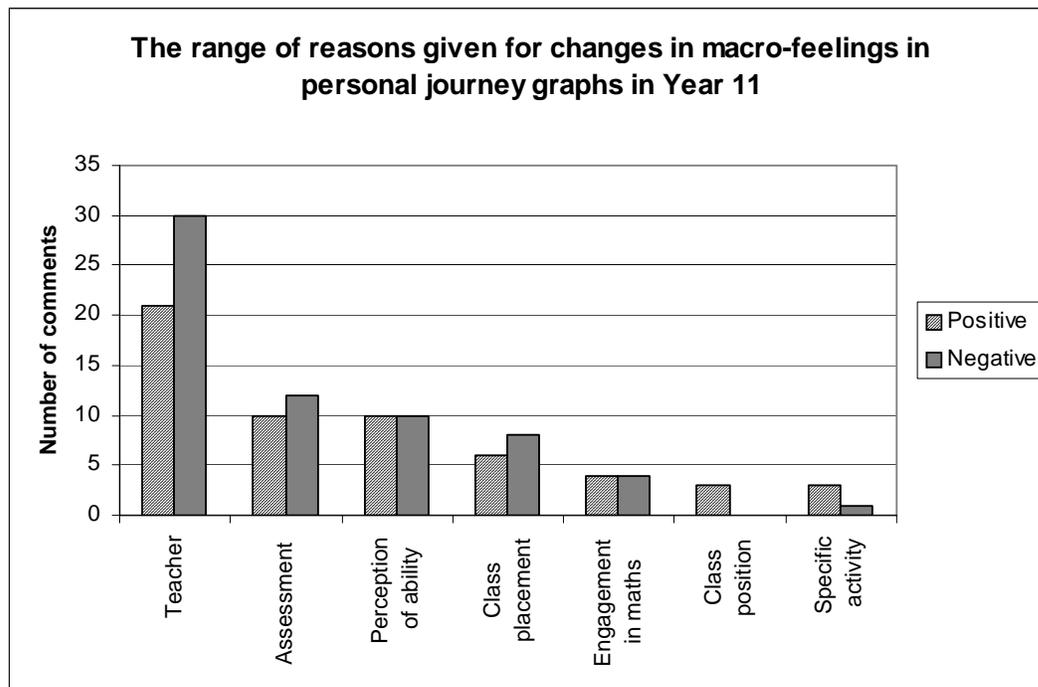
It is perhaps not surprising that the students often associated their mathematics teacher with these routines, the difficulty of mathematics, and their overall dislike of the subject. Asked to comment on some of the events they experienced during their mathematical journey, the students wrote 122 comments on their personal journey graphs. Many of the comments were written when students' feelings changed from negative to positive or vice versa. Just over half (53 percent) of these comments were when their feelings became more negative. Among the range of comments (see Figure 6.4), 42 percent of comments were related to the students' mathematics teachers, and 18 percent related to their examinations. 16 percent related to students' perception of their ability to do the mathematics. According to these comments, having a particular mathematics teacher had a significant impact on how the students felt about mathematics as a subject.

The comments were written in a group situation, which may have contributed to their content. Nevertheless, the comments do indicate that the students' macro-feelings about mathematics were conditional on their teacher to some degree. This was confirmed from data collected with other research tools, in which the students indicated that the teacher was associated with their macro-feelings about mathematics.

I think the maths teacher you have affects the way you feel about maths  
(Angela<sub>EndofYear10</sub>).

Maths is bad because Miss Cotton doesn't teach it properly (Joanna<sub>GroupInterviewYear11</sub>).

It's fun, because Mr Powell makes it fun (Jennifer<sub>GroupInterviewYear11</sub>).



**FIGURE 6.4** Reasons given for changes in macro-feelings

There is risk in isolating the teacher as the factor that most affects students' feelings and engagement. The teachers in this research were significant participants in the community of the mathematics classroom. Through their choice of tasks, the routines of the mathematics class, where they allowed the students to sit, through their interactions with the students and through recognising and rewarding students, the mathematics teachers, with the students, co-constructed the social norms of the mathematics classroom. Other issues such as checking uniforms, homework, or the teacher's position in the school may have influenced the students' perceptions of their mathematics teachers. A student's mathematics teacher is the human face of school mathematics for both themselves and their parents. The students received some empathy and possibly reinforcement about these feelings from their family. Tracey, in the quote below, is re-voicing the opinions of her grandfather and uncles.

My grandfather and my uncles have all said if you don't like your teacher you're not going to like your subject and it's kind of true (Tracey<sub>InterviewYear10</sub>).

Here, Tracey is making sense of her experiences in the classroom and her feelings about the subject by re-voicing the opinions of her family. Like the students' discussions of the

importance of mathematics (section 5.2.2) she is negotiating the different meanings between home and the classroom.

That the students perceived their feelings about mathematics to be strongly affected by their mathematics teachers can be found in other research. In Grootenboer's (2002) discussions with New Zealand pre-service primary teachers about their school mathematics experiences, mathematics teachers were the most significant feature of their discussions. This may have been because, as pre-service teachers, they were focussed on teachers. Averill (2009) collected ethnographic data from six Year 10 classes in New Zealand using observations, teacher and student interviews, and questionnaires. She examined the complexity of participants' views about the importance and development of teacher-student relationships in the classroom. Averill (2009) found that teacher-student relationships were considered by teachers and students to be influential on students' overall motivation and achievement in mathematics. Specifically, if a student "liked" a teacher, they were more likely to be motivated to engage – they were likely to listen, want to do well in their work, and feel confident that the teacher would support them when they needed assistance. Certainly in the current research, the students associated their motivation to engage with their teacher.

Last term my feelings about maths changed. The teacher didn't really push ... it was an opportunity to lax out in one class. You just couldn't learn anything  
(Cheryl<sub>InterviewYear10</sub>).

When we had Mr Murray I didn't really feel motivated to do it at all  
(Katrina<sub>InterviewYear11</sub>).

The students thought that mathematics teachers needed particular skills because of the unique nature of the subject and the feelings students had about it.

It's different for maths than other subjects. [A maths teacher needs to have] patience. Tolerance and (Saskia rocks her arms as if she is holding a baby) the comforting skills (Saskia's voice softens) like to calm someone down or to comfort them when they're having a hard time learning (Saskia<sub>InterviewYear11</sub>).

A good mathematics teacher explains things fully and well maybe in a few different ways because some people don't always respond to certain ways. It's tough and ... people don't like [it] (Corrina<sub>GroupInterviewYear11</sub>).

How well the students' perceived that a teacher could explain concepts and their manner when giving help had an effect on the students' pathways of engagement. When a student became confused with a task, their perception of their teacher's explanation and manner affected their help-seeking behaviours.

I like it this year because if you've got a question, Mr Powell's always been able to answer and explain (Ann<sub>GroupInterviewYear11</sub>).

Miss Hill wasn't really the best teacher for me personally ... it's hard to explain ... I'll think about it (Jason pauses for five seconds). A personality type thing. Mrs Brown's ... a lot better at helping me with things if you don't understand something. Miss Hill will ... explain it, but it's really hard to understand the way she explains things. She'll just tell you sort of (Jason<sub>InterviewYear10</sub>).

When I asked her for help she doesn't give very good help. She helps you for like 30 seconds and then sees someone else with their hand up and then just goes to them for help and doesn't finish off what she's saying. She doesn't even say, 'I'll be back in a minute' (Susan<sub>GroupInterviewYear11</sub>).

The students also felt rushed if the teacher is inaccessible or hurried when they ask for help.

Jennifer: A good maths teacher is one that, if you don't understand something, they don't just explain it and then go I'm off ... they sort of help you understand it better. They don't go this is how you do it and then you don't understand.

Jill: Yeah, they don't expect you to just know it ... they keep going through it if you don't understand it (JenniferJill<sub>GroupInterviewYear11</sub>).

The students were asked what the teacher could do better to help them cope with negative macro-feelings about mathematics. There were two aspects to the students' answers. They wanted the routines of the mathematics classroom changed and they wanted the teacher to get to know them better.

The students talked about how small variations in classroom routines and the introduction of social aspects might improve their feelings about mathematics. There was a sense too that they needed to understand the purpose of classroom routines such as homework, lesson starters, textbooks, and assessments.

Maths teachers need to have variation in their lessons (Robyn<sub>GroupInterviewYear11</sub>).

We need to do more hands on work like measure things and stuff. Getting up and walking around. I like to do hands on stuff. To make me feel better I'd need to do more of that (Alasdair<sub>AutobiographyYear10</sub>).

Connor: [Teachers need to] play more games.

Naomi: Should maths be all about having fun though?

All: Yes!

Connor: Yeah. You only live once ... Just anything. Not always just from a textbook (ConnorMarkPhilip<sub>GroupInterviewYear11</sub>).

[They've got to] play more games to demonstrate the work we do in our books (Jill<sub>BiographyYear10</sub>)

Susan: Even making us make posters or something. Just something. Just not the same work over and over.

Dawn: Do a range of things and whatever gets the most response.

We do a starter every single day. I don't know why (Cheryl<sub>InterviewYear10</sub>).

The students also said teachers needed to get to know them better to improve their feelings about and learning of mathematics.

Everyone in the class is different. There are no people who are alike and ... the maths teacher needs to change or adapt their teaching style to fit everyone and it's a really hard thing to do because not everyone can be pleased. ... The teachers need to know how [we] learn (Angela<sub>GroupInterviewYear11</sub>).

It's not just [students'] maths [teachers need to get to know], it's how the students feel about their maths ... Even if they like maths or not. Just taking an interest. They need to care about you and maths ... I reckon more kids would pass because the teacher would know them (Ruth<sub>GroupInterviewYear11</sub>).

The students had various suggestions for how their teacher could get to know them better. Many of the students thought the mathematics autobiography and interviews used in this research were useful for getting to know them better, though this response perhaps could be

more to do with pleasing me, rather than their actual views. More formal tools such as writing a letter to the teacher at the start of the year were also suggested by the students. Colin, for example, suggested writing the teacher a letter but cautioned that, over a year, a student's feelings about mathematics could change.

[If] it only happened once at the start of the year and you could completely change  
(Colin<sub>GroupInterviewsYear11</sub>).

Other suggestions were for the use of more subtle techniques.

I think a lot of the time you can maybe tell how they feel about it by the way they work or what they look like when they come into the classroom and things like that. A good maths teacher needs to be able to read people's faces (Dawn<sub>GroupInterviewYear10</sub>).

Just talk to the students (Bridget<sub>GroupInterviewYear11</sub>).

Averill (2009) also found that students' mathematical experiences were likely to be enhanced by teachers who knew the students as individuals and as mathematical learners. This had a slightly different focus than the findings in this research. In this research, the students wanted the teacher to get to know them better to understand and improve their feelings when they had difficulty with the work or received results. The students in Averill's (2009) research perceived that, if the teacher knew about their lives outside of the classroom, this would help their mathematical learning. By knowing the students better, the teachers were able to use real life contexts relevant to the individual students. Interestingly, some of the students in Averill's (2009) research felt it was harder in mathematics than in other subjects for the teacher to get to know them. These students perceived that, in mathematics, there were fewer spontaneous opportunities for linking the mathematics they were doing with their personal lives. The teachers with more caring relationships with their students in Averill's (2009) research created opportunities for multiple one-to-one interactions during the mathematics lessons. These interactions were both focused on students' lives outside the classroom and students' mathematical learning and progress. Through these interactions, the students and teachers got to know each other.

Indeed, there was a sense that the students also needed to get to know their teachers better. Students did not understand how the mathematics teachers could enjoy the subject of mathematics.

Sean: [Mathematics teachers] have to like the subject I suppose.

Mark: People who are super-enthusiastic about maths are scary jerks. It's just scary (SeanMark<sub>GroupInterviewYear11</sub>).

Robyn: Maths teachers need to be enthusiasts!

Amanda: Some are really enthusiastic about some things but don't say why. But it's the boringest [task] in the world ... yeah that says a lot about them (RobynAmanda<sub>GroupInterviewYear11</sub>).

Not only did the students distance themselves from mathematicians (section 5.2.2), they distanced themselves from their mathematics teachers. To the students, it was not rational that their mathematics teacher could like and be enthusiastic about a subject they considered to be so boring (section 5.2.4).

### 6.1.2 Micro-feelings

Micro-feelings were the feelings students experienced when they were engaged in a specific mathematical task. They were important to study because of the way the students associated them with their macro-feelings and their engagement in mathematical tasks.

The students described a range of both positive and negative micro-feelings that occurred at different levels of intensities and depended on the context of the mathematical situation.

I am happy when I do something right, boring, tiring, pain in the bum, sometimes difficult, wishing the class would end, plain old strange (Ruth<sub>InterviewYear10</sub>).

The students experienced micro-feelings before, during, and after assessments for example. Immediately before an assessment the students felt different degrees of nervousness. They often had anxiety-related micro-feelings during an assessment, and they got nervous waiting for test results to come back.

I felt a little bit nervous before the test ... [I] just like ... need to do well. I am aware that I need to try my hardest (Sean<sub>InterviewYear10</sub>).

If it's a test or something I might panic a little ... especially if I didn't really pay attention. ... Everybody panics in tests (Nicola<sub>InterviewYear10</sub>).

[In the test the other day] I was worried that I didn't really do very good. I didn't do some of them (Mark<sub>InterviewYear10</sub>).

Similar to their macro-feelings about mathematics, the students perceived mathematics to be different from other subjects in terms of the frequency of negative micro-feelings. Students therefore felt more negatively about the subject of mathematics, in general, and experienced more negative feelings as they engaged in the specific mathematical activities.

Negative feelings just happen more in maths [than other subjects] so it affects students more (Katrina<sub>GroupInterviewYear11</sub>).

There was a relationship between students' macro and micro-feelings. McLeod (1992) described an attitude to mathematics as developing "from the automatising of a repeated emotional reaction to mathematics" (p. 581). DeBellis and Goldin (2006) similarly talked about students developing global affects when they experienced established and recurrent local affects. Similarly, the students described their macro-feelings as developing when they experienced repeated and frequent micro-feelings.

Micro-feelings turn into macro-feelings when they start building up and you realise that you're not getting it and you've pretty much failed the year and you can't catch up (Ruth<sub>GroupInterviewYear11</sub>).

Little things turn into big things when there are lots of them. And when there's lots of bad things you feel bad, but if there's just one of them you're just like whatever (Katrina<sub>GroupInterviewYear11</sub>).

In contrast to findings from the other research, the students also described macro-feelings as developing when they experienced micro-feelings of significant intensity. When very intense, micro-feelings were not transitory and likely to become longer-term macro-feelings about mathematics. The feelings Moira experienced at primary school, in Figure 6.1 (section 6.1) for example, was an emotional response to a particular situation. It was a micro-feeling of sufficient intensity to potentially become a longer-term macro-feeling about mathematics. Robyn describes the transformation between micro-feelings and macro-feelings.

Micro-feelings turn into macro-feelings when they re-occur. Day, after day, after day. Or if it is a micro-feeling [and] it really does upset you heaps. Like if it's a three [for its level of intensity]. It does affect you for a while (Robyn<sub>GroupInterviewYear11</sub>).

Presented below is an example of when many of the students experienced intensely negative micro-feelings to an algebraic problem given to them in Year 10.

Mr Murray wrote the following on the board and asked students to answer it in their exercise books:

Simplify

$$\frac{4a^2b^3c^6}{3bd^2} \times \frac{2ad^3}{3b^2c^4}$$

There was a visible and audible reaction from the students. Some students swung back in their chairs, others looked at each other, dropped pens, or opened their books. For some students, their mouths dropped open and they shook their heads. Amongst the tumult, students' individual voices can be heard. "You're joking", "OOOhhh", "Oh", "I don't know how to do that", "The memory's not good for some people", "Nooooo", "I'm going to fail", "I don't get it" "What?" Joanna sat up quickly, her mouth opened and her eyes widened. She gasped and shook her head, fumbled for her pen, threw it back down. After this initial reaction some students asked the teacher to clarify, e.g., Jason asked whether the index of the 2ad in the numerator of the second term was a 3 or a 4. Katrina said "That's my answer." After two minutes, Mr Murray asked "Have you finished?" Someone said "I don't get it. Not many people do". Mr Murray then gave a brief explanation of the procedure, wrote the answer on the board, and moved on to the rest of the lesson (Observation<sub>MayYear10</sub>).

The students initially experienced a variety of micro-feelings when they first encountered the problem. Joanna, for example, described reacting with surprise at the level of difficulty in the starter. Ruth describes her initial feeling.

I nearly died because it looked hard (Joanna<sub>InterviewYear10</sub>).

We just about fell off our chair ... we looked at it and we were like WOW (Ruth<sub>GroupInterviewYear10</sub>).

When the students encountered a mathematical task, they were each in a unique learning situation. They had different interpretations of the physical and social context of the moment

and were experiencing different situations in their life outside the classroom (section 5.1). They had different views about mathematics (section 5.2) and the specific task. They also had different macro-feelings about mathematics and algebra (section 6.2.2).

This problem, which was given as a starter, was the first time the students had encountered algebra in Year 10. Their macro-feelings about algebra, which developed the previous year, would have contributed to the context of the micro-feelings they experienced. For many of the students, this incident would have reinforced their already negative macro-feelings about algebra.

Naomi: Tell me about your worst maths experience  
Alasdair: Algebra! Oh I hate it ... just the letters and numbers  
(Alasdair<sub>InterviewYear10</sub>).

The students engaged in the algebraic problem in different ways, according to their habitual pathways of engagement, their interpretation of the context, and other aspects of their relationship with mathematics. Jason asked for clarification. Joanna wrote the problem down carefully but did not write any working or an answer (Joanna<sub>ExerciseBookYear10</sub>). Around half the class had not attempted the problem before the teacher gave the answer. Others completed the problem to some degree. None of the students got the answer correct. Each student had unique pathways of micro-feelings and engagement in the algebraic starter.

I didn't even attempt it because I didn't know how to do it like I didn't know how to attempt it (Joanna<sub>InterviewYear10</sub>).

When [the teacher] put that starter on the board, I felt confused a little bit ... like not knowing what to do and stuff (Sean<sub>InterviewYear10</sub>).

I just couldn't be bothered. I probably couldn't have done it anyway but ... I just gave up (Mark<sub>InterviewYear10</sub>).

Discussion of this starter problem led to further discussions about the different ways the students associated their micro-feelings with their thinking, learning, and engagement in mathematics. To some extent, the students described their engagement to contribute to their feelings. Moira, quoted in section 5.1, worked ahead of the class in order to feel better about doing the mathematics. Connor attributed his positive feelings, to his engagement in the

mathematics. Jill talks about feeling happy and proud because of her engagement and success in a task.

I just wanted to do the work. ... Then you do good in it ... then you're happy  
(Connor<sub>GroupInterviewYear11</sub>).

When I have successfully worked out something hard I feel happy and proud of what I  
have achieved (Jill<sub>Metaphor</sub>).

The students usually described aspects of their engagement as an outcome of their feelings. Malmivuori (2006) explained, in her research, that affect both directed or disturbed students' thinking. The students described learning experiences where their micro-feelings affected their thinking.

I couldn't ... sometimes when I do maths I like I won't get it and I'll start freaking out  
and I won't remember the ... what I'm supposed to be remembering ... like it will  
escalate because I'm freaking out so much (Saskia<sub>InterviewYear11</sub>).

Saskia's intensely negative micro-feelings of "freaking out" affected her ability to access her mathematical knowledge. Her thinking was disturbed because she experienced what Mandler (1989) described as a reduction in conscious capacity (section 2.2).

More often, the students described how their micro-feelings affected their engagement in the mathematical task. DeBellis and Goldin (2006), in their research on mathematical problem solving (section 2.3) talked about how local affect carried meaning for individuals. Affect was a meaningful signal to change strategy. In this research, students' micro-feelings certainly contributed to their pathways of engagement. In other words, the students talked about how their micro-feelings during mathematical activity affected the ways they usually engaged in a mathematical task. It affected their concentration, the amount of work they did, the depth to which they did that work, and their perseverance.

I think what I mean is I get most of the [boring] stuff out of the way quickly. Some of  
the stuff I take my time on (Peter<sub>InterviewYear10</sub>).

If I'm enjoying it, I'll do a lot better ... concentrate more (Jennifer<sub>InterviewYear10</sub>).

When I'm feeling really good about maths it helps me grab concepts faster and they stick in my brain for longer (Robyn<sub>GroupInterviewYear11</sub>).

When I feel bad about maths ... when I feel like that I can't be bothered to do maths ... I don't ... I don't learn stuff (Paul<sub>GroupInterviewYear11</sub>).

When you feel good about it, you feel more confident and excited to learn about it (Debbie<sub>MetaphorYear10</sub>).

Sean and Ann tell of similar micro-feelings, yet their pathways of engagement are different.

Not getting it ... I think I get like ... Nuts! [Naomi: Nuts?] Frustrated. A little bit stressful ... and you have to work on it (Sean kicks out his foot) (Sean<sub>InterviewYear10</sub>).

[I get] kind of frustrated when I can't do something ... I just give up (Ann<sub>InterviewYear10</sub>).

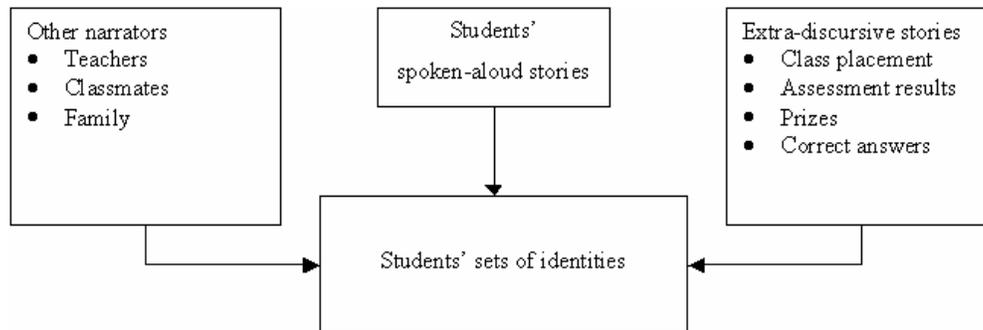
Although their micro-feelings were similar, their interpretation and responses to those micro-feelings were different. In the discussion about what mathematics teachers could do to improve students' feelings about the subject (section 6.1.1) Robyn talks about this type of situation

Mathematics teachers need to get to know the kids and understanding what sets them off. It's an individual thing. Two students get the same result back but they mean different things (Robyn<sub>GroupinterviewYear11</sub>).

Students' had different interpretations of their micro-feelings and different pathways of engagement because of their unique interpretation of the context of the moment (section 5.1), their views of mathematics (section 5.2), and their macro-feelings about the subject. When the students described how mathematics made them feel, either when they were engaged in a specific activity (micro-feeling), or about the subject overall (macro-feeling), these feelings and the resulting engagement were also associated with their mathematical identities. To further understand why students interpret similar micro-feelings or results differently, their identities need to be explored.

## 6.2 Identities

As discussed in earlier chapters, identities are the reifying, endorsable, and significant stories that are told about each student. In this research, each student had a unique set of mathematical identities that included stories that students told about themselves and stories from other sources floating around that were adopted by the students. The stories from other sources were the stories told by teachers, classmates, and the students' families, and the extra-discursive stories of class placement, assessment results, correct answers, and prizes. To be included in students' sets of identities, the stories from other sources needed to be of significance to the students and endorsed by them. Figure 6.5 shows the groups of stories that potentially make up a student's set of identities.



**FIGURE 6.5** Stories that have the potential to become identities

It is not intended in this diagram to imply that these groups of stories are independent from each other. The stories students tell about themselves are both formed by and contribute to the stories told by others. Extra-discursive stories such as prizes and assessment results also contributed and are related to the stories that students tell about themselves. Stories from other narrators and extra-discursive stories are similarly dependent on each other.

### 6.2.1 Being good at mathematics

In this research, the mathematical identities recognised in data were related to the students' perceptions and expectations of their ability in mathematics. 'Ability' was a term commonly used by the teachers and parents of the students.

Connor has shown outstanding ability and understanding in all we have covered in class (MrsBrown<sub>ReportAugustYear10</sub>).

Maths is not her favourite subject. [Her] ability to handle maths varied through schooling (NicolaDad<sub>QuestionnaireYear10</sub>).

A student's *ability*, in this sense, is their capacity to solve the tasks they encounter in mathematics. The students rarely used the term 'ability'. Rather, they usually used the words "good at maths" or "bad at maths". Bridget and Jill's perceptions of their mathematical ability are examples of actual identities. Detailed in section 4.4.2, an actual identity is an objectification of a person about what is happening at the time (Sfard & Prusak, 2005b). In other words, these are assertions about Bridget and Jill's ability in mathematics.

I just don't think I'm good at maths (Bridget<sub>EndofYear10</sub>).

I don't think I'm bad but I'm not good at maths either (Jill<sub>AutobiographyYear10</sub>).

In research described in section 2.2, Zan and Di Martino (2007) conceptualised a student as having an emotional disposition to mathematics which was made up of their liking or disliking of mathematics, their perception of being able to do it or not, and their vision of mathematics. This is similar to the results of this research – each student had a unique combination of view of mathematics – like/dislike – I can do/can't do. The strongest association was between I dislike/I can't do mathematics. Although Zan and Di Martino (2007) described the combination I can do it/I dislike mathematics to be rare, the students in this research seemed to hold this view more frequently (section 6.1.1), attributing their dislike to boredom. Furthermore, the students generally shared the common view of mathematics to be unique from other subjects in its nature, its level of difficulty and the feelings of boredom it generated.

The students constantly collected evidence that contributed to their perception of how good they were at mathematics through their interactions with their classmates, family, and teachers. These groups of people were, in general, significant in the students' lives and the stories told by them were also potentially significant. Classmates rarely told students directly how good at mathematics they perceived them to be. Rather, students' gained evidence of how good they were themselves through the comparisons they made with their classmates and their positioning in the class (discussed in detail in section 6.2.2).

Through their interactions with their children, parents contributed to students' perceptions of how good they were at mathematics. The students adopted identities from stories floating

around including their family's views of their achievement and progress. The students' parents spoke of expectations about mathematics-related careers, courses their children should take, and expectations of achievement. For many of the students, the parents' were significant contributors to their views of the importance of mathematics (section 5.2.2) and provided stories out of which students could form identities.

Angela has always been capable at mathematics, even from an early age. I have not noticed any changes in her ability, other than the obvious progression through various stages of difficulty (Angela<sub>DadQuestionnaireYear10</sub>).

Mum and Dad. I think they're pretty pleased with my maths (Angela<sub>InterviewYear10</sub>).

Section 6.1.1 described how the students associated their macro-feelings about mathematics with their mathematics teachers. The teachers' perceptions of how good the students were at mathematics were generally significant to the students, and most of the students had an opinion of what the teachers thought of their mathematical ability. This is an interesting contradiction, given the students wanted their teachers to get to know them better to improve their macro-feelings (section 6.1.1).

Through interacting with their teachers, the students gained evidence of their teachers' perceptions of their ability, and these contributed to their actual identities.

And she won't be hearing any of this? I reckon Mrs Brown just thinks I'm average probably, and I think that's probably true (Jason<sub>InterviewYear10</sub>).

Teachers may think I'm kind of not really good at maths. Yeah. I just don't think they see me as being that good. The teacher tries to explain it ... he can probably tell sometimes I get confused (Paul<sub>InterviewYear10</sub>).

That the students had a clear picture of what their parents and teachers thought of their mathematical capabilities has consistency with the students surveyed in the NEMP project (section 6.1.1). Three quarters of the Year 8 students in 2009 were able to assess how good their teacher thought they were at mathematics, and 85% indicated they were aware of their parents' view of their ability in mathematics (Educational Assessment Research Unit, 2011)..

Students' reports directly indicated to the students their teacher's view of their ability. They were significant to the students because their parents also had access to them, and they were an official document kept by the school and used potentially for future employers. Many of the comments on the students' mathematics reports had the potential to be strongly reifying actual identities, because of their statement of the students' current achievement or ability to participate in the mathematics. Nicola's report, for example, clearly stated her teacher's perception of her ability. Nicola had read this report, and it was significant to her.

Nicola is a good mathematician. Her results in the recent assessment were pleasing  
(MrsBrown<sub>ReportYear10</sub>).

I just look at my reports and think I'm doing well ... I'm not terrible  
(Nicola<sub>InterviewYear10</sub>).

Students' reports, which contributed to students' perceptions of how good they were at mathematics (section 6.2) also indicated gaps between what the student should be doing and how they were currently doing.

Peter is a talented mathematician who has achieved many pleasing results throughout the year ... With a little more care I am confident that he will achieve an "Excellence" grade in the end of year exam (MrPowell<sub>EndofYearReportYear11</sub>)

It is possible, that when Peter read this report, he may have known that his teacher believed him to be a talented mathematician and this may have contributed to his own set of actual identities, as "I am a talented mathematician".

The teacher felt I was pretty good at it mostly because of what he saw from test results  
(Peter<sub>GroupInterviewYear11</sub>).

Peter also might have understood from this report that his teacher expected him to achieve an Excellence grade in the end of year exam. This may have become part of his set of designated identities. "I need to achieve Excellence grades". Certainly Peter was seeking Excellences in mathematics in Year 11 (section 7.1). The teacher suggests a gap existed because of a lack of care. If Peter also believed there was a gap between his actual and designated identities, he may have experienced negative feelings, but there is no evidence of this.

Saskia's report is another example of a source of students' actual and designated identities.

Saskia's focus is too often on peripheral matters such as her social life rather than on mathematics. She has only achieved 4 credits offered to date

(MrCarter<sub>MidYearReportYear11</sub>).

Although Mr Carter did not make a direct statement about Saskia's mathematical ability, he states that she has received "only 4 credits offered to date". When the report was written, the class had been given the opportunity to gain 11 credits, so this statement, particularly with the word "only" is a suggestion that possibly reinforced for Saskia that she was not achieving and evidence she was not meeting her designated identities. In other words, she was not meeting the expectation that she should be focusing on mathematics and gaining all 11 credits. Though again there is no evidence of this, Mr Carter's report would probably have been accompanied by very strong negative micro-feelings from Saskia, because, although she acknowledged her social focus, her parents' views were especially significant to her.

There was a lot of bad things happened ... People change in Year 11. People change like a lot of my friends have which kind of sucks but you find out who's your good friend. You can't focus [on maths] (Saskia<sub>InterviewYear11</sub>).

In my maths ability the [teachers] think like I'm okay at it but could do some work (Saskia<sub>InterviewYear11</sub>).

The thing that worries me the most in maths is that I'll fail and my parents will kill me (Saskia<sub>InterviewYear10</sub>).

Saskia is aware of her parents and teachers' expectations. She worries about failing, and knows she needs to work on the mathematics more, yet her social needs affect her focus on the mathematics. These stories are a further example of the contradictions found in the students' stories. Students' messy lives were reflected in their contradictory identities, views, and feelings about mathematics.

The students mainly gained evidence of how good they were at mathematics through their doing of mathematics. "Being good" at mathematics was an important theme in this research, as was "being able to do" the mathematical task. Being able to do each mathematical task provided evidence to students that they were good at mathematics, and students' perceptions

of how good they were at mathematics provided the context for localised perceptions about whether they could do a task. In other words, students who thought “I am good at maths” also thought “I can do this task”. Expectations of overall success in mathematics provided the context for localised expectations at each moment of engagement in the mathematics. Being able to do the specific mathematical task was evidence for a student that they were good at mathematics overall. Many aspects of engaging in the mathematics provided evidence for the students about how good they were at mathematics. Correct answers were satisfying, even pleasurable to the students (section 6.1.2), because they were evidence of their ability to do the problem and thus engage in the mathematics. Failure to solve a problem was potentially, for the student, evidence that they were not good at mathematics.

If I fail something or get lots wrong, or I don't know how to do something, I think I'm hopeless at maths (Joanna<sub>EndofYear10</sub>).

When I'm shopping, I can't really do discounts. I'm not very good with percentages (Cheryl<sub>InterviewYear10</sub>).

In this research, the students' perceptions of how good they were at mathematics were particularly important because they were associated with their macro-feelings about mathematics (section 6.1.1), and their engagement and participation in the subject of mathematics.

Corrina, for example, disliked mathematics because she was bad at it. She had disengaged in the subject throughout her journey.

Well, I hate it. I was just like bad at [maths]. I didn't like get it ... completely ... and I was always be a bit afraid to ask for help. I was just like bad at it or something and it was always known as like my worst subject ... it was sort of a belief I guess ... I always sort of gave up on it in primary school ... everyone was going come on it's so easy you can get this ... and I just can't do this and I probably spent my last year like drawing (Corrina<sub>interviewYear10</sub>).

There was a gap between her actual and designated identities. Her actual identities were to do with being bad at mathematics, and yet, at that stage, she felt she should understand it better. Corrina hated mathematics. Her macro-feelings were situated in the gap between her actual and designated identities. Corrina no longer participated in mathematics when it became non-

compulsory at the end of Year 11 (Corrina<sub>SubjectChoiceYear12</sub>). Her designated identities relating to wanting to understand it better did not remain for long. Her dislike of mathematics resulted in her not pursuing the career she was interested in. Mathematics was not part of Corinna's set of designated identities in the sense it was not contributing to her future life.

I wanted to do something in tourism like maybe like a travel consultant ... but then I found out like ... it was all maths like it was mostly mathematics. I thought it was like sort of like helping out and things like that. I thought it would be more people related. The job would be mostly mathematics. Yeah ... I'd like more people related things rather than doing lots of mathematics equations and things like that  
(Corrina<sub>InterviewYear11</sub>).

Sfard and Prusak (2005a) talk about students experiencing a sense of unhappiness when there is a perceived and persistent gap between their actual and designated identities. Corrina was very unhappy because of her perceived gap between her identities, and this resulted in her no longer participating in the subject. She reduced her expectations – her designated identities to close this gap.

Peter, on the other hand, who felt he was good at mathematics (section 6.1.1), also discontinued with mathematics in Year 12. Like the student in Shannon's (2004) case study in New Zealand, Peter's decision surprised the school (MrsMirren<sub>FeedbackYear12</sub>), because he was considered to be so competent. Peter, however, after being compelled to sit in a subject he had disliked for years (section 6.1.1), fully disengaged with mathematics because he believed his chosen career did not require mathematics (Peter<sub>AutobiographyYear10</sub>). Peter was frustrated and bored to an intense level (section 6.1) with school mathematics. Despite his evident ability in the subject, the field of mathematics has lost Peter because it did not offer him enjoyment, enrichment or any qualifications that he perceived that he needed.

There are similarities between the students' perceptions of being good at mathematics and research into confidence or self-beliefs. Although there are difficulties interpreting related research due to a lack of clarity of terms (section 2.2), McLeod (1992) described these self-beliefs as an important affective factor in mathematics classrooms. Indeed, self-beliefs have been linked to achievement, engagement, and participation (Kloosterman, 2002). In Corrina's case, as with the other students, there are strong associations between students' perception of being able to do the mathematics, their macro-feelings, participation in the subject, and engagement in the mathematical tasks.

Corrina had a “belief” she was “bad at maths” and that it was her worst subject, which was something that was not going to change. Many of the students in this research seemed to have an entity view of their intelligence (section 2.3). They believed “how good” they were at mathematics was fixed, rather than as function of their present skills and knowledge. People were “maths type” people, or not.

Maths is like sport – not everyone is good at it (Katrina<sub>MetaphorYear10</sub>).

My Mum’s not good at maths because she couldn’t do it at school. She’s not really a mathematician type person. She’s more the arts kind of (Ben<sub>InterviewYear10</sub>)

According to Ryan and Patrick (2001), students who have an entity view of intelligence believe that performance in mathematics is affected more by innate ability than by effort. They do not, therefore, understand the benefits of engagement. Dweck (1999) similarly explained that students who believed their intelligence is fixed may minimise the effort they put into their schoolwork. The way the students engaged was messy though. On the one hand, they did seem to understand that they needed to engage in their schoolwork (section 5.1), yet their engagement was affected by their views of mathematics, the context of the moment of engagement, their feelings, and their perceptions of their ability.

Students had different expectations of success in a task because of their perceptions of their mathematical ability and their set of designated identities. When these expectations were met by their progress, they experienced positive or neutral micro-feelings.

I feel happy [in maths] when I understand what I am doing the first time and can do it (Ann<sub>EndofYear10</sub>).

I feel okay as long as it’s not hard! (Frank<sub>InterviewYear10</sub>).

Ann thought she should understand what she was doing the first time and should be able to do the mathematics in the task. She felt happy when this occurred. Frank had neutral feelings when he did not experience too much difficulty when he was doing the mathematics.

Students had their most positive micro-feelings when they received evidence that they had done better than expected. In other words, their actual identities exceed their designated

identities. These students, for example, experienced very positive feelings when they achieved a grade higher than they were expecting in their assessments.

Last year for the maths exam, I thought I was going to fail Algebra ... I was going to get Not Achieved and I got Excellence and I was like oh my gosh and I was like real surprised ... and I was like oh man that's good (Moiria<sub>GroupInterviewYear10</sub>).

The best maths experience I ever had was ... when I've gotten Excellences when I wasn't really expecting them (Lola<sub>InterviewYear10</sub>).

[I feel good in maths when] ... like when you pass something that you actually didn't think you were going to pass (Debbie<sub>InterviewYear10</sub>).

Section 5.1 described students with different pathways of engagement. Students' perceptions of how good they were at mathematics affected these pathways. Some students did not attempt difficult problems because they felt it was beyond their mathematical ability.

I'm not even going to attempt to do that, because I know I won't be able to do it so I just kind of ... (Jill<sub>GroupInterviewYear11</sub>).

In Sullivan et al.'s (2006) research, which took place outside a classroom, the students engaged in the task, even when they expected to experience difficulty. Jill engagement in mathematical task, however, was affected by her expectation of difficulty. Furthermore, for the students who did attempt difficult problems, their level of engagement depended on their perception of their ability and their confidence that, if they persevered, they would be able to work out how to do the task.

If you're feeling bad you don't have much confidence to do it. So you sort of don't like strive. If you're feeling good you just like tackle problems like it helps you like go for it really (Corrina<sub>GroupInterviewYear11</sub>).

Maths is like a Rubik's cube because those who can't do it think it's complicated and often don't persevere with it (Katrina<sub>MetaphorYear10</sub>).

If you're feeling good it's like yay, [and] if it's ... hard you try to figure it out (Jennifer<sub>GroupInterviewYear11</sub>).

When I feel bad about the maths and I see a really, really hard problem, it's just like if you can't do it, you feel bad and you stop trying (Susan<sub>InterviewYear10</sub>).

When I think I've got it and I'm all excited. Yay! (Saskia yells) I've got it and I do all of [it] (Saskia<sub>InterviewYear11</sub>).

If a student had difficulty with a mathematical task, they experienced negative micro-feelings. These micro-feelings occurred because a gap appeared in their expectations "I should be able to do this problem" and their progress "I can't do this problem". Like Sean and Ann (section 6.1.2), the students could have similar micro-feelings during a task, but these micro-feelings do not necessarily lead to similar engagement. The students' descriptions of their experiences of micro-feelings during a task are similar to the way Hannula (2002) explained students' evaluation of their progress and emotions during a task.

While a student is engaged in a mathematical activity, there is a continuous unconscious evaluation of the situation with respect to personal goals. This evaluation is represented as an emotion: proceeding towards goals induces positive emotions, while obstacles that block the progress may induce anger, fear, sadness, or other unpleasant emotions (p. 29).

When a student experienced difficulty with a problem, asking for help was a common strategy. The students' seeking of help was affected by their feelings about their teachers and their perceptions of their teachers' helping behaviours (section 6.1.1). Generally, however, those students who were most comfortable with their mathematical ability asked for help more than students who did not perceive they had good mathematical ability.

When you understand something, you go for it. You actually try. You ask for help if you need it (Tracey<sub>GroupInterviewYear11</sub>).

Well I'll try and do it first, then I'll probably ask if I don't understand it. Umm ... sometimes ... and then I just ask and ask and ask until someone finally gives me an answer that I understand (Amanda<sub>InterviewYear10</sub>).

Tracey and Amanda engaged in the mathematical task to a high level. They asked for help more. They were committed to learning the process rather than simply seeking the correct

answer, demonstrating mathematical integrity. In other words, they were committed to searching for mathematical understanding.

Tia and Moira, who did not feel they were good at mathematics, felt it was pointless to ask for help from the teacher because they would not understand it anyway.

I don't like always asking for help because Mrs Brown tries to explain it and I don't get it. If I keep asking when I don't understand I feel really stupid (Moira<sub>GroupInterviewYear10</sub>).

I don't like asking for help because I feel like a dumb-arse. The teacher will come and help me and they'll explain it and go away and I still don't get it. The really brainy ones like Angela and Robyn and Colin when they ask for help they always [understand] ... it's just like they know it (Tia<sub>InterviewYear10</sub>).

Asking for help and still failing to understand the mathematics or know what to do in the task was evidence to Tia and Moira of their mathematics ability – actual identities. They felt stupid and like a “dumb-arse” in this situation.

Students had different levels of performance in a mathematical task, and they experienced further micro-feelings as they interpreted the final result – whether it was completed successfully or not. The students experienced these micro-feelings because they interpreted the meaning of these results. Failure or success in a problem were evidence of their progress in mathematics – and contributed to their actual identities relating to their mathematical ability. Not attempting a problem or giving up early in a problem often resulted in further negative micro-feelings because the students were experiencing a gap between how they expected to do in the task and their actual performance in the task.

I'll have a go at [a hard problem]. I do what I do normally ... to work it out and then if that doesn't work ... I feel really bummed because I couldn't do it and then sort of move on (Alasdair<sub>InterviewYear10</sub>).

If it seems easy enough, I'll try it. If it looks really long and complicated, I'll just not do it. Skip it. Then I feel weird, like I wasn't trying to do my best (Sean<sub>InterviewYear10</sub>).

I try and ask someone and I just give up. I just leave it and move on to the next one, but that kind of worries me, because if I leave half of them I don't know how to do

them. I don't know what to do. [I feel] kind of annoyed that I can't get it. Frustrated  
(Nicola<sub>GroupInterviewYear10</sub>).

When a student performed or progressed at a lower level than they were expecting, this was potentially evidence of their ability and therefore an actual identity. Depending on the meaning they derive from this performance, their expectations of success in future assessments may change to incorporate this result. They might expect a similar result the next time. An actual identity therefore could become part of their designated identities – and therefore part of their expectations the next time they encountered a similar mathematical task.

There were two themes that emerged from exploring students' stories and the identities within. The students had gaps in their identities related to the class they were placed in by the school (class placement), and how good at mathematics they perceived themselves to be compared to their classmates (class positioning). The themes of class placement and class positioning and their associated feelings and engagement are explored in the next sections.

### 6.2.2 Class placement

The students were placed in different mathematics classes in Years 7, 8 and 11 depending on their teachers' judgement of them and their mathematics assessment results. In Years 9, the research students were placed together in the achievement class and stayed together for two years until the end of Year 10 (section 4.2). Being placed in the achievement class, or in MAT101 in Year 11 was generally a source of pride for the students, which made them feel good. For explanation on the different mathematics classes in Year 11, see section 4.2.

I feel good [about being in the achievement class] ... because I get to brag about it  
(Amanda<sub>InterviewYear10</sub>).

[I had the best year ever in maths] ... because I was in the top class. [I felt good]  
because I was in the top class (Joanna<sub>InterviewYear10</sub>).

Only one student did not enjoy being in the achievement class or MAT101. For Alasdair, being in the achievement class was not necessarily negative but certainly a sense of difference from other students at the school.

It's fine being [out of the achievement class]. I just don't stick out any more. It's all right. Oh, like in the achievement class, it's like 'you're in the achievement class', and now I've sort of blended back in. I'm in the middle (Alasdair<sub>GroupInterviewYear11</sub>).

Even though the students in the achievement class were chosen on the basis of their literacy, rather than on their general or mathematics achievement, the students were not aware of this. The students generally adopted the institutional story of being in the achievement class or MAT101 as a common actual identity. It was, for them, an overall indication that they were good at mathematics. 29 out of the 31 students (Students<sub>EndofYear10</sub>) felt they were above average in mathematics compared to other students in their year level *because* they were in the achievement class. Only Moira and Tia described themselves as average or below average in mathematics compared to students in other classes.

I am probably the worst at mathematics in class ... Out of my [year level] I guess I would be average (Moira<sub>EndofYear10</sub>).

In my class I'm very bad. In all of year 10, I'm still not good (Tia<sub>EndofYear10</sub>).

The students described a number of expectations because they were in the achievement class or in MAT101 that were different to the expectations of students in other classes. It was the students' perception that the school, their parents, their teachers and their classmates commonly held these expectations. These related to both success overall and expectations when they encountered specific problems. They also related to their engagement in the mathematics. In Op 't Eynde's (2004) words, the students engaged to actualise their identities. The students felt they needed to engage fully in the mathematics and have good classroom behaviour. They were expected to achieve to a high level and be able to understand the mathematics quickly. The students potentially drew designated identities from the common expectations associated with their class placement.

Everyone expects us to do really well (Susan<sub>InterviewYear10</sub>).

People expect that you're going to get the question right (Bridget<sub>InterviewYear10</sub>).

In the last class, it was sort of like I was never part of the class ... like it was the class and Corrina ... The class had kind of a very short attention span. It is a bit better [in

the achievement class] because everyone is not so ... they don't misbehave all the time (Corrina<sub>InterviewYear10</sub>).

It's MAT101 so most of them [are] wanting to work (Ann<sub>GroupInterviewYear11</sub>).

Angela directly questioned some students' inclusion in the class because of their engagement in the mathematics, comparing their engagement with students in other classes. She implied inclusion was a privilege.

I don't understand how some of the people got in [to the achievement class]. They just take it for granted and don't do the work. I know. One of our other best friends works really hard and she's not in our class and sort of it irritates me how some people in our class don't do the work and stuff (Angela<sub>InterviewYear10</sub>).

Alasdair and Katrina, discussing some of the students in their MAT101 classes, were surprised at the students' exclusion from the achievement class the previous year. Alasdair considered the decision was because of their lack of engagement in the mathematics. In other words, for the students' to be in the achievement class or MAT101, Alasdair's expectation was that they should be committed to learning and involved in the mathematical tasks.

Alasdair: There's people that should have been in the achievement class last year. I don't know what that means but ... (Alasdair pauses for two seconds).  
But they wouldn't have like applied themselves. There's people like Bruno Johnson. He's really really good at maths but he just wouldn't have applied himself. Just doesn't do any work

Katrina: Charlie got Excellence in his test [this year] but none of me and Angela and Ben did. Charlie wasn't in the achievement class [last year].

Alasdair: He wouldn't have applied himself either. He's a bit distracting!  
(AlasdairKatrina<sub>GroupInterviewYear11</sub>).

The mathematics teachers contributed to and reinforced these commonly held expectations through their teaching. Mrs Brown, the main mathematics teacher in Year 10, described her method of teaching this class as "exactly the same as a normal Year 10 class but at a faster pace" (MrsBrown<sub>InterviewYear10</sub>). Later in this year, Mr Murray told the students about an imminent assessment, stating his expectations clearly.

Here, most of us will be a Merit towards Excellence class ... that's what you're here for. (Cheryl shakes her head and Mr Murray addresses the next comment to her).

There'll be some people only working towards Achievement

(MrMurray<sub>ObservationJune1Year10</sub>).

In Boaler, Wiliam and Brown's (2000a) research, they similarly described how mathematics teachers set expectations in classes considered to be of a higher ability than other classes (described as high-set in their research).

Students in high sets came to be regarded as 'mini-mathematicians' who could work through high-level work at a sustained fast pace ... this suggests that students are *constructed* as successes or failures by the set in which they are placed as well as the extent to which they conform to the expectations the teachers have of their set (Boaler, Wiliam & Brown, 2000a, p. 643).

A number of issues emerged from Boaler, Wiliam and Brown's (2000a) research. The students experienced discrimination from students in other classes because of their class placement, as well as anxiety because of competition and pressure. They also experienced difficulty because the pace of the lesson was often too fast for them. There are some similarities here as students in this research felt a sense of difference from students in other classes. However, there was no evidence of discrimination from students in other classes (see section 7.1.2 for Colin's comment about nerds). The students, with the exception of Alasdair, felt positively about being in the class. Some of the students experienced a heightened level of competition, which is discussed below. The view that mathematics had to be learnt at a fast pace was part of the students' view of school mathematics detailed above. Yet when students could not keep up with the learning pace, students experienced difficulty and negative feelings. Being in the achievement class or MAT101 perhaps contributed to this view of mathematics as a face-paced subject, and the resulting feelings associated with this view therefore may be partly attributable to class placement.

Students compared their actual identities with the commonly-held class set of designated identities. When students perceived they did not meet the expectations related to their class placement, negative feelings were experienced or they questioned their class placement. Paul, for example, did not feel some of the other students met the expectations of achievement and questioned their membership in the class, and when he experienced difficulty, he also felt that he should not be in the class.

There is some people [in the achievement class] that sometimes I kind of can't see why they're in there and sometimes I feel like one of them in a few subjects if I don't get it ... Sometimes I work stuff out slower than the other people, because there is quite a lot of people that are smarter at maths than me in the class (Paul<sub>InterviewYear10</sub>).

Moira also perceived she did not meet the expectations of being in the achievement class.

I feel kind of stupid because everyone else in our class is like real smart because it's the smart class and does everything and gets everything done but I just sit there and I'm the only one that needs to work it out you know (Moira<sub>GroupinterviewYear10</sub>).

She did not “get everything done”, and did not think she was “real smart”. Moira perceived she was the only one in the class that needed to think at more than a superficial level about the mathematics (section 5.2.3). She “just sat there” and was the “only one that needed to work it out”. As a result, she felt “stupid”. There was a gap between her actual and designated identities and she experienced negative feelings, which were related to her perception of not being good at mathematics. Moira's unhappiness was profound and she questioned her class placement.

The students in Boaler, Wiliam and Brown's (2000a) research described the students experiencing negative feelings when they did not meet their teachers high expectations of them. In the current research, the students described these negative feelings. Students' experiences with Algebra in Year 9 were an example of when there was a gap in their designated and actual identities, but their resulting negative feelings were not necessarily related to their perception of how good they were at mathematics. Many of the students had negative macro-feelings about algebra and talked about intensely negative experiences when learning the algebra topic the year before. Susan, for example, hated the topic.

Mr Toomey wouldn't teach us anything. He'd just expect us to know it ... all this complicated algebra stuff. He wrote down one thing I remember it was ... umm ... lengthen these equations and he didn't explain it or anything and when he wrote it up he made it even shorter ... like ... he changed it to something different and he didn't tell us how he did it. He didn't tell us anything. He didn't explain it. He just expected us to know it. I hate algebra. It's just confusing (Susan<sub>InterviewYear10</sub>).

When the students had learned algebra in Year 9, many of them were not able to do the work, as they felt they did not meet the common designated identities of the achievement class. They therefore experienced negative micro-feelings. However, the students also perceived the teacher's expectations had exceeded the commonly held set of designated identities associated with class placement. There was a gap between what the students perceived they were capable of doing and what the teacher expected them to do because they were in the achievement class. This affected their views of him as a teacher, and it led to intense micro-feelings. In Susan's comments, there was use of the words 'us', suggesting a sense of solidarity with classmates, which may have contributed to feelings about the teacher or the subject, rather than students' perception of their own ability. These micro-feelings contributed to macro-feelings about the topic of algebra (section 6.1.2). Whilst at the same time, the feelings were tempered by the students' understanding that the teacher had exceeded the commonly held designated identities of the class placement and in this way had broken the didactic contract that had formed over the year. Mr Toomey did not, according to the students, teach in the manner expected of him during that topic. This resulted in the students' negative feelings being more focussed on him and the subject of algebra, rather than being associated with not being able to do the work, though this was a factor too.

### **6.2.3 Class positioning**

The students also perceived they needed to be good at mathematics and be able to do the mathematics in *comparison to their classmates*. They had individual designated identities to do with being able to work and achieve to the level of their expected positioning within the class. These positions were constantly evolving as students learnt more about their classmates and their own relative positioning. Gaining evidence about classroom positioning and what other students could do was important to the students.

[I miss being in the achievement class because] last year was our second year we'd all been together and like everyone just gets to know everyone and works well and knows what each other can do (Jill<sub>GroupInterviewYear11</sub>).

When [my friend didn't pass] like she said I'm a bit embarrassed because only three of us didn't pass that (Maira<sub>InterviewYear11</sub>).

Interestingly, the students felt their progress in mathematics was more evident to others than in other subjects. They could write a sentence or paragraph in English and from a distance it

was not so obviously wrong. In class discussions, the students described mathematics as a “visual” subject. For them, it was more obvious to others when they had difficulty in beginning, completing, and gaining the correct answers on a problem. Lack of progress was shown by a blank exercise book or crossings out, calculator use, or the incorrect answer marked with a cross in red pen (ClassDiscussionYear10). During one mathematics lesson, for example, Moira was particularly self-conscious when the principal saw her struggling on what she perceived to be easy questions.

I feel cabbagey because the other day ... it's like I've really dumbed down in maths.  
[The principal] came in and he saw I was like struggling on these really easy questions  
(MoiraGroupInterviewYear10).

This was, for Moira, a snap-shot of how good she was at mathematics. It was an actual identity. She perceived that she was discovered lacking, and therefore experienced negative micro-feelings, particularly because of the public aspect of her lack of progress. Newstead (1998), studying mathematics anxiety in nine to eleven-year-old students, raised the question that perhaps it was the public aspects of doing mathematics in the presence of teachers and peers which evoked mathematics anxiety.

Later in the same interview, Moira and Ruth described very mercurial micro-feelings when they were working on a group of similar textbook questions. When they perceived they could do the mathematics, they felt positive. This evidence then perhaps raised their expectations for the next problem in the group of problems. When they did not get that correct they were embarrassed, because of the public aspect of their progress.

Ruth: If I get something right ... it's (Ruth gives a whoop of joy) oh yeah. We're like working through questions and yay we can do this one!  
Moira: And then the second one ... we're like damn (Moira says 'damn' loudly).  
Ruth: The other day we were given questions and we were getting them right and we were like. Yeah! We're onto it. But then like if I try and get it wrong I'm just like I'm going to embarrass myself (RuthMoiraGroupInterviewYear10).

When the students perceived they were at the same level mathematically as each other, there often seemed to be a form of positive competition between them, further increasing their engagement. Dawn and Connor, for example, had sat next to each other in Year 10. Sean and Jason sat near each other in Year 11.

Last year ... me and Connor were always competing so we both tried really hard (Dawn<sub>GroupInterviewYear11</sub>).

Sometimes I feel competitive. Me and Sean sometimes might have a race ... who comes first sort of thing ... when we've done tests, I always see who's done what, and see who's done better ... he actually helps me work ... like challenging each other ... [to] beat him and stuff. He's about the same level as me so we work on hard problems together (Jason<sub>GroupInterviewYear11</sub>).

The comparisons of students considered to be in the top group of mathematicians were more overt with each other and were therefore perceived to be more competitive than other students. It should be noted that the students were not formally in a top group, but were those students informally known to be good at mathematics by the students and the teachers. The students in the top group relished this competition and the ensuing mathematical discussions.

[I'm] a little bit [competitive]. I try and beat Angela and Colin because they are the ones who beat me in the end of year exam last year (Katrina<sub>InterviewYear10</sub>).

There are a few who are above me (Peter<sub>AutobiographyYear10</sub>).

Being competitive. That's not like me. That's between Peter and Colin and people like them. I don't compare myself with them. They're a lot better than me at maths (Nicola<sub>InterviewYear10</sub>).

I could do long division before Peter could. I had to bask in the glory ... and then I taught him how (Colin<sub>InterviewYear10</sub>).

On the other hand, comparisons between students who were not the same level as each other mathematically generally resulted in negative feelings. Students felt more comfortable with comparison when they were at the same level as them mathematically.

[Last year], you had Colin and Peter ... and they'd be like 'Oh, I'm doing all this' (Tia says the words in the single quotation marks in a high, mocking voice). Angela would always get the top mark in class but everything to her was 'I need to get better than Colin' (Tia again puts on the mocking voice) and I thought would you shut up because I just want to get an Achieved (Tia<sub>GroupInterviewYear11</sub>).

It depends who I'm with. ... I'm competing with someone at the same level it's good, but if they're at a higher level it kind of takes the fun out of it because ... I'm behind always (Jason<sub>GroupInterviewYear11</sub>).

I like [working with others] just as long as I'm in the same playing field as them. Got to be the same level (Alasdair<sub>GroupInterviewYear11</sub>).

There were constant comparisons among classmates. These comparisons were, for the students, evidence of being able to do the mathematics compared to other classmates – potential actual identities. When there was a gap between students' designated and actual identities relating to class positioning, students experienced feelings.

[I feel anxious] when I don't understand something and everyone else does (Sean<sub>EndofYear10</sub>).

Every now and then, I'll do this huge working out with all these sums and problems and everything because that's how I see it sometimes and then there's like a real simple way everyone else does it like a nice neat way (Jason<sub>InterviewYear10</sub>).

It was quite cool [understanding] it ... because other people were just sitting there looking completely confused but if you get it, it's cool (Angela<sub>InterviewYear10</sub>).

Sean and Cheryl experienced different feelings when they compared their experiences with trigonometry. Sean described his difficulty with trigonometry and his perception that he had not been able to do it compared with his classmates.

Sean: This year I was like ... oh crap I've got trig again because last year I didn't really get it ... everyone else [this year] was like ... so easy and I was oh ... yeah.

Cheryl: Oh, I love it (Sean groans and Cheryl smiles cheerfully)  
(SeanCheryl<sub>GroupInterviewYear11</sub>).

Sean already had negative macro-feelings about trigonometry because he had previously experienced difficulty in understanding the topic. These contributed to his anxiety (negative micro-feelings) about doing the topic again. Sean perceived he should find trigonometry easy because everyone else did (designated identity), and yet he experienced difficulty (actual

identity). Cheryl then said that she loved trigonometry. By also implying that she found it easy, she was positioning herself above Sean. Sean experienced further negative micro-feelings, groaning as Cheryl confirmed his perception of a gap between his actual and designated identities.

When a student received evidence of their ability to do the mathematics (an actual identity), they both compared this evidence to their individual expectations of success and compared it to how they should be doing according to how their classmates had done (designated identity). Their feelings adjusted according to how their evidence compared with what they perceived their own positioning within the class to be. Sean and Lola talk about their surprise when they received their assessment results.

I only got Achieved [in the test] ... I was a bit gutted because I kind of expected I would have got a little bit more ... because I tried ... hard. I asked around and it seemed like most people got Achieved. Even some of the people I expected them to get ... like Joanna and stuff ... I asked them what they got and they were like I got Achieved and I was like what? (Sean<sub>StudentInterviewYear10</sub>).

I was surprised that I got Merit for [the] measurement [unit] because I heard that a lot of people got Not Achieved ... and I thought that I hadn't done very well (Lola<sub>EndofYear10</sub>).

The teachers reinforced the students' positioning within the class. As discussed in section 6.2.1, students usually had a perception of what their teacher thought of their mathematical ability. When a teacher interacted with a student, the student sometimes formed a perception of what the teacher thought of their ability to do the mathematics in comparison to their classmates.

It's just like the way Mr Murray kind of talked to me like I'm not as smart as the rest of the people ... talked to me like I'm dumb (Paul<sub>InterviewYear10</sub>).

Amanda: (says the following three sentences in a low, angry voice) I hate it when they're condescending. They give you that stupid voice and look. The 'you should know this' look.

Frank: Oh that ... the 'didn't we do this last year' look?  
(AmandaFrank<sub>GroupInterviewYear11</sub>).

This was potentially an actual identity – evidence of Paul’s ability in mathematics. Mr Murray was, in Paul’s view, highlighting a gap between Paul and the rest of the class.

At times, the teachers reinforced the students’ positioning within the class by assigning different work to students. Colin, Angela, and Peter were considered by the students to be the top mathematicians. To a lesser extent, Katrina was also known to be extremely able at mathematics. The top group of students in Year 10, in particular, often got work that extended them past the syllabus of the year. Peter enjoyed Mr Murray’s attention and often was given extension work to do when he finished early.

I’ve learnt lots of new things this year because Mr Murray knows that I know it so he’s teaching me new things. I got to do differentiation! I can differentiate numbers now. When we’ve finished all our work Mr Murray would teach us new things. It’s those things that weren’t in the curriculum that he’s taught us that other people [didn’t get taught] (Peter<sub>InterviewYear10</sub>).

This advanced content was evidence to Peter of his ability in mathematics and he enjoyed his positioning that this new content signified. Rather than Peter being given tasks that enriched him at the current level, he was given new procedures that extended him past Year 10 mathematics. He perceived that he could differentiate because he was taught the rule for differentiation but had no relational understanding of the concept or intimacy with the beauty of calculus. This introduction of new content would perhaps have contributed to his boredom in subsequent years because of its repetition when he encountered it with the main body of the class. Sadly, he did not take mathematics after Year 11, and therefore did not meet calculus in school mathematics again (section 6.2.1).

Teachers reinforced students’ positioning within the class by choosing students to be involved in mathematical events outside the classroom.

The best maths experience I’ve ever had ... I think we did ... we had to go down to the university and do some challenge thing a few years ago. Aah, I think it was [because I was in] the top three in the school (Connor<sub>InterviewYear10</sub>).

Miss Hill just said do you want to do [the extension maths group at the university] and I said oh okay. Colin and Peter went in Term two and I went in Term 3. [I enjoyed it] because we got to do like some sort of practical working out theories for ourselves,

and then proving how to do stuff like Algebra. Actually using it to prove it. It's quite fun (Katrina<sub>interviewYear10</sub>).

Teachers were also observed to comment on students who had done particularly well, or seek indications of success after assessments. Already conscious of others' achievement, the students were sometimes made even more aware of what mark their classmates got.

At the end of the quiz, Mr Murray asked the class who got 10. Alasdair quickly puts hand up and smiles widely. Joanna, Angela, Peter, Sean, Philip, Connor, Katrina and Amanda also put their hands up. The students looked around at each other (Observation<sub>MayYear10</sub>).

The mathematics teachers also chose which students to award a Progress or Excellence prize to at prize giving. Only three of the students (Alasdair, Jill, Tia) stated that winning a prize in mathematics would make them feel uncomfortable (Autobiography<sub>Year10Year11</sub>). Many students described receiving a prize or award as their best experience in mathematics (Interviews<sub>Year10</sub>). Being awarded a prize is a very public form of recognition because the recipient is seen by the school and reported in the newspaper to the community. This, again, positions the students within the class.

Connor: Miss Cotton gives you [prizes]

Philip: She did too.

Connor: At assembly, [Philip] got [a prize] from the teacher for being a good boy.

Philip: Shut up! (ConnorPhilip<sub>GroupInterviewYear11</sub>).

The mathematics teachers also positioned students within a mathematics class by choosing specific students to answer questions posed to the whole class. They used this questioning technique to help to explain a concept by getting the students 'involved' in understanding the procedure by answering the question in stages. When a student answered a question correctly in front of the class, this was evidence (potentially an actual identity) of that student's ability and position in the class.

Katrina likes to participate a lot more [than others]. I think she's very able at maths and she likes to be part of what's going on. It makes maths better for her if she can be participating and getting some success by getting the right answers. She sits at the back but she puts her hand up ... you can't miss her. She's always got something to say (Mr Carter<sub>FeedbackYear11</sub>).

When a student answered a question in class, their willingness to do so depended on whether they felt they were able to do the mathematics and could get a correct answer. Mark, differently to how he behaved in other subjects, did not put his hand up in mathematics, whereas Katrina, who felt she was good at mathematics, did.

Naomi: How do you behave in maths compared to other classes?

Mark: Yeah, I won't put my hand up to answer any of the questions, because I think I'll get them wrong.

Naomi: And are you more inclined to put your hand up in other classes?

Mark: Yeah (Mark<sub>InterviewYear10</sub>).

Whether a student answered questions in class also depended on whether they were given the opportunity to answer the question by the teacher. The students in the top group put their hand up to answer questions in front of the class more than the other students and were encouraged to do so by the teacher. Indeed, the teacher often sought answers particularly from those in the top group. During one observation in Year 10, the teacher asked a series of verbal questions to check students' understanding. Except for one other person, who was not asked to contribute, only Colin and Angela put their hands up for the entire session (Naomi<sub>ObservationYear10</sub>). Indeed, Angela became very conditioned to answering questions in class.

Angela gave all the answers today when Mr Murray was explaining how to measure the volume of a box. He did not check for understanding from anyone else, so the explanation went at Angela's pace (Obversation<sub>June13Year10</sub>).

Mr Murray: Why do you think all women should use the internet rather than going to the shop?

Angela: So they don't go to the shop and buy everything  
(MrMurrayAngela<sub>ObservationJuneYear10</sub>).

I must have been on auto-pilot or something ... I must have just done it because I knew that was the answer he wanted. I didn't actually believe it. I didn't even notice I had got into that sort of pattern ... he probably shouldn't have asked me because I knew all the answers (Angela<sub>InterviewYear10</sub>).

Angela's perception that the teacher asked her because she knew all the answers may have been correct. Boaler (2002b) described how the pace of the mathematics lesson, dictated by

the amount of content needing to be taught, affected the questioning of students from the board during explanations. Teachers in a rush “did not waste time on students who could not provide correct answers” (Boaler, 2002b, p. 33).

Every time a teacher ‘recognised’ a student by seeking them to answer a question, or by rewarding them, giving them extra work, or selecting them for external mathematics activities, this became a story that potentially added to the students’ set of actual identities about their own and others’ ability. The students considered in the top group, in particular, had their positions reinforced by the teacher. Students who were not considered to be in the top group, but considered themselves to be good mathematicians felt excluded and as a result felt frustration because of lack of acknowledgement. Amanda, for example, did not perceive herself to be recognised as one of the top group of students by the teacher. Despite feeling able to do the mathematics, and meeting or exceeding the commonly held designated identities of the class, she was excluded from mathematics competitions and external projects only requiring two or three people, often because she perceived the teacher automatically asked those in the ‘top group’ or had an expectation it was those people who would be included. These exclusions were stories that she did not accept as actual identities of how good she was at mathematics. Amanda’s negative feelings were not to do with her ability to do the mathematics. They were to do with her frustrations with the teacher.

It’s a little bit annoying because I always finish everything first because no-one did anything and there was always Peter up the end doing special problems and it was like okay I’ll just continue with my work. Yeah, sometimes it gets really annoying because I’m good at maths. Why can’t I do that? (Amanda<sub>InterviewYear10</sub>).

Halfway through last year I just kind of got sick of everyone. I just like wanted to leave ... Mr Murray just completely ignored me (Amanda<sub>GroupInterviewYear11</sub>).

When you’re [finished your work] you’re sitting there and you’re like okay what do I do now? And they just completely (Amanda places emphasis on the word ‘completely’) ignore you. I go ‘I’m finished’ and they go ‘oh yeah, is that right?’ and they just move on. Mr Murray did that all the time (Amanda’s voice quietens when she spoke the last sentence) (Amanda<sub>GroupInterviewYear11</sub>).

[A good mathematics teacher] is one who pays attention to the whole class, not just the people at the lower levels or the higher levels of the class  
(Amanda<sub>GroupInterviewYear11</sub>).

Every time the teacher focussed on students considered to be in the top group, this also became a story about others' ability to do the mathematics. Being excluded was potentially an actual identity that reinforced students' positioning in the class, and ensured students experienced negative feelings about their ability and the teacher.

[The top group would] always be asked [questions in class]. In maths last year it was really hard because Angela would always answer (Tia<sub>GroupInterviewYear11</sub>).

Miss Hill normally pays more attention to the smartest ones like Katrina and Colin  
(Jason<sub>InterviewYear10</sub>).

Mr Murray ... only really focussed on the people who got it. Not the people who didn't (Nicola<sub>GroupInterviewYear11</sub>).

I haven't noticed Debbie at all ... She's average in the class ... not like the good people like Katrina or Angela or Peter even, but above average in Year 10  
(MrsBrown<sub>InterviewYear10</sub>).

Mark's just quite happy to sit there and do his work and sort of blend into the background ... doesn't like participating at all. He's one of those falls-through-the-cracks kind of students that you can't really say much about because unfortunately you don't know so well. Unless they're really noisy or participate a lot (Mrs Brown<sub>InterviewYear10</sub>).

Gaps between students' identities that related to class positioning emerged as an important theme because it was associated with students' engagement in the mathematics. Furthermore, these constant comparisons between classmates have specific implications for the seating arrangements in the class, and these are explored now.

### 6.3 Seating arrangements

The students interacted at some level with all of their classmates, but they were particularly aware of and interacted with those sitting next to them *and* those in close proximity (section

4.4.1). Students compared their mathematical progress and success with the progress and success of these students. Through these comparisons, as described in section 6.2.3, they gathered evidence of their own and others' ability. These comparisons resulted in the students experiencing a range of micro-feelings. Section 5.1 described how the students' social nature affected their engagement. The social nature of the students and the multitude of comparisons between students had implications for the success of the seating arrangement in the classroom, and these implications are explored in this section.

During the research period, the students entered their mathematics classroom and either sat according to a prescribed seating plan or sat where they wanted. Seating plans are not unusual across subjects or schools in New Zealand, especially in the first term of the year. They enable the teacher to learn the students' names and separate social groups, thus contributing to a perceived improvement in classroom discipline. During the first 10 weeks of Year 10, the research students were seated in pairs in an alphabetic seating plan in their mathematics class. For the rest of the year, the students remained in pairs and chose where to sit. In Year 11, the students were in self-choice seating in pairs or groups, depending on desk arrangement. Where they chose to sit remained fairly static over time.

The students described more positive feelings and higher engagement in the mathematics when two conditions operated with their seating arrangements; *other students' behaviour did not negatively affect them*, and they *felt comfortable* with the classmates they were sitting near. This comfort was associated with both being at the same level as them mathematically and liking the other person. Knowing and liking each other was important to this class of adolescents, and whom a student sat near affected student comfort and talk, both in terms of mathematical discussion and asking for help.

It's always scary if you're not next to someone who you know and can talk to and won't think 'Ha! You're an idiot' .... If I'm with a friend, I feel good ... I'm in a good mood when I'm around my friends which means I'm more willing to try  
(Saskia<sub>InterviewYear11</sub>).

If I sit next to friends ... it makes me feel more comfortable because ... we help each other. If I sit beside someone I don't like or don't know ... I don't feel comfortable asking them (Bridget<sub>InterviewYear10</sub>).

They need to let us pick where we sit so I'm more comfortable (Ann<sub>AutobiographyYear10</sub>).

Jason: You could be [with] people at your level. That might be all right.

Peter: If I was ... with Colin, I would be fine with it (PeterJason<sub>GroupInterviewYear11</sub>).

When students sat near others they perceived were at the same level as them, these comparisons resulted in positive feelings, increased levels of comfort, and increased engagement (section 6.2.3). Many students, aware of the mathematical progress of students considered to be in the top group, said they would feel uncomfortable sitting next to someone in the top group. Cheryl, who perceived that her mathematical ability was very different to Colin's, described how she would feel sitting next to Colin.

If I sat next to Colin I would feel stupid ... he's really smart (Cheryl<sub>InterviewYear10</sub>).

Given Colin's description of Cheryl, she had good reason for her discomfort.

Cheryl is quite a challenge for me to explain something to because sometimes it's really funny that she doesn't know it and I'm laughing on the inside. I take a deep breath and explain it to her (Colin<sub>InterviewYear10</sub>).

Colin and Cheryl were at a different level from each other mathematically which contributed to negative feelings. Perhaps adding to these negative feelings, the students in the top group were often expected by their classmates and teacher to be available for help. Being a constant helper was a role not necessarily enjoyed by students in the top group.

They just keep bugging me (Peter sounds increasingly frustrated). They just keep asking 'what do you do?' ... [The teacher has] told us what to do ... just write and do it (Peter<sub>GroupInterviewYear11</sub>).

At other times, sitting near to Colin, Angela, Peter or Katrina could, be positive for the students, especially if they were friends of theirs. "Brainy as" is an expression for someone who is very brainy.

Last year I sat beside Katrina and she's like brainy as. She just like knows everything and whenever I got stuck, I'd ask her and she'd help me (Debbie<sub>GroupInterviewYear11</sub>).

Explaining ... is beneficial as it helps clarify things for me (Katrina<sub>EndofYear10</sub>).

I'm happy to help them ... If I don't know how to explain it to them I'll just tell them to ask Colin or something (Katrina<sub>InterviewYear10</sub>).

Wanting to be close to their friends was related to the students' need to have an element to their mathematics lessons that was social and not necessarily related to the mathematics.

You still need your social time (Debbie<sub>GroupInterviewYear10</sub>).

[I would feel better about maths if] the teacher doesn't make us work in complete silence so by talking I feel more relaxed (Peter<sub>AutobiographyYear10</sub>).

The students also wanted the opportunity to learn mathematics socially.

Maths, it's a subject where talking helps you ... talking to the people beside you helps more than when you talk in English. So if you're silent, you don't learn as much (Ann<sub>GroupInterviewYear10</sub>).

To feel better about maths I need the teacher to let us talk and work with the people we sit with (Jill<sub>GroupInterviewYear11</sub>).

The teacher needs to let us discuss it with the people around us. She doesn't always let us but we do it anyway (Susan<sub>AutobiographyYear10</sub>).

Like the students described in Nardi and Steward's (2003) research, the students in the current research seemed to "celebrate the support they can offer each other" (p. 353). Being able to talk about mathematics helped the students' enjoyment and engagement in the mathematics. This result is consistent with other research. Ryan and Patrick (2001) found an important element of the classroom environment was the extent to which students were encouraged to interact with their classmates. They found that students did not typically become more disruptive when they were encouraged to talk with one another during lessons.

Many of the students also said they worked best with one other person or a small group situation.

I learn best in a small group because there are more possible questions and answers coming from people (Jason<sub>AutobiographyYear10</sub>).

I like to work in partners so if we don't understand something we can help each other out (Jennifer<sub>AutobiographyYear10</sub>).

I need to work with a partner or in a small group because they can help you and you can discuss it with them (Bridget<sub>AutobiographyYear10</sub>).

I learn best in a small group because different people can provide different ideas, which makes me think about things in different ways (Katrina<sub>AutobiographyYear10</sub>).

Yair (2000) associated group work and classroom discussions with the highest rates of engagement and teacher's lectures as the lowest rates. Ryan and Patrick (2001) describes how small group work encouraged students to reflect on their own problem-solving strategies by exposing them to alternatives. Prawat and Nickerson (1985) said that teachers who placed equal emphasis on cognitive and affective outcomes in the mathematics classroom are those teachers who frequently used small groups. In a Year 10 statistics class in New Zealand, cooperative learning was found to enhance indicators of students' learning. In other words, the cooperative learning enhanced students' interest and enjoyment, engagement in the task, ownership of the mathematical concepts, the quality of their inquiries, their own task behaviour and accountability, and their achievement (Ingram, 1995).

Despite their need to learn mathematics socially, the routines of school mathematics, with its dominating use of individual textbook work (section 5.2.1), reinforced the students' perception that mathematics should be done in isolation. The students' social nature was considered to be detrimental to the students' engagement in mathematics.

Ben works well in class, despite social nature (MrsWhite<sub>FeedbackYear11</sub>).

Indeed, in section 5.1, the students described how their classmates distracted them from their doing of mathematics, and how they had difficulty in controlling their own behaviour because of their strong social needs. The students wanted to work and talk together but they needed and expected help to balance these needs. Many of the students confessed that sitting with friends was often difficult because of social disruption, their own distraction, or being at different ability levels. They acknowledged that they may need to sit somewhere else to engage better in the mathematics but seemed generally powerless to do so. All of the students acknowledged that they needed the help of their teachers to prevent others from affecting their learning through seating plans.

If I wanted to do my work really well, I wouldn't sit with [my mates]

(Jason<sub>InterviewYear10</sub>).

[If I got to choose where I sat all the time] I wouldn't learn anything. That's where

seating plans help (Ben<sub>InterviewYear10</sub>).

Most of the students, however, stated they did not like seating plans in their written responses. Indeed, only two of the students stated an unreserved approval of seating plans. Corrina, who wrote in her end of year questionnaire in Year 10 that she did not like seating plans, had a different view when interviewed individually.

I need a seating plan. If I sit next to someone I don't really like, I concentrate more and I'll do my work. I shouldn't be saying that (Corrina<sub>InterviewYear10</sub>).

In summary, when the students sat near students who they felt comfortable with and who did not distract them, their enjoyment and engagement in the mathematics was enhanced. The students did more work, and they talked about the mathematics more together. The students needed the teacher's support in the form of seating plans to ensure the seating arrangement was positive.

## 6.4 Students' relationships with mathematics

The students in this research had relationships with mathematics that had five elements.

1. Views of mathematics
2. Macro-feelings
3. Identities
4. Mathematical knowledge
5. Habits of engagement

Figure 6.6, below, summarises the process of change in students' relationships with mathematics. Each student had unique views of the nature, importance, and difficulty of mathematics and a perception of how boring the subject was. They had macro-feelings about the subject of mathematics overall. Each student had a unique set of identities related to their view of their mathematical ability. They had designated identities about their overall expectations about the subject, which included commonly held expectations of class

placement, individual expectations relating to class-positioning, how important they viewed mathematics to be, and how they expected the subject to contribute to their future life. The students also had actual identities – perceptions of how good they were at mathematics. These developed through their interactions with their teachers, parents, and classmates, and through their experiences of success and failure when they engaged in the mathematics. The students had different levels of mathematical knowledge, a term that the students mainly used in relation to their knowledge of mathematical rules. The students also engaged in the mathematics in habitual ways that developed over time. Among these habits were the students' pathways of engagement – the ways they usually engaged in a mathematical task.

In Figure 6 below, it was difficult to capture the complex ways the elements interacted. Students' macro-feelings were associated with their views of mathematics and were situated in the gap between their actual and designated identities. The students' mathematical knowledge was closely linked to their view of the nature of mathematics. The way students usually engaged in mathematics was associated with their macro-feelings, their views of mathematics, and their identities.

The elements of students' relationships with mathematics were both shared by the classroom community and unique to the individual. For example, the class shared common views about their expectations of their teachers and common designated identities relating to their class placement, yet had very different macro-feelings about mathematics, and individual perceptions of their own mathematical ability.

These relationships continuously developed throughout students' mathematical journeys, and were both historical and social. The elements in the relationship were modified or reinforced by personally significant mathematics learning experiences, which in turn were shaped by their engagement in mathematical tasks.

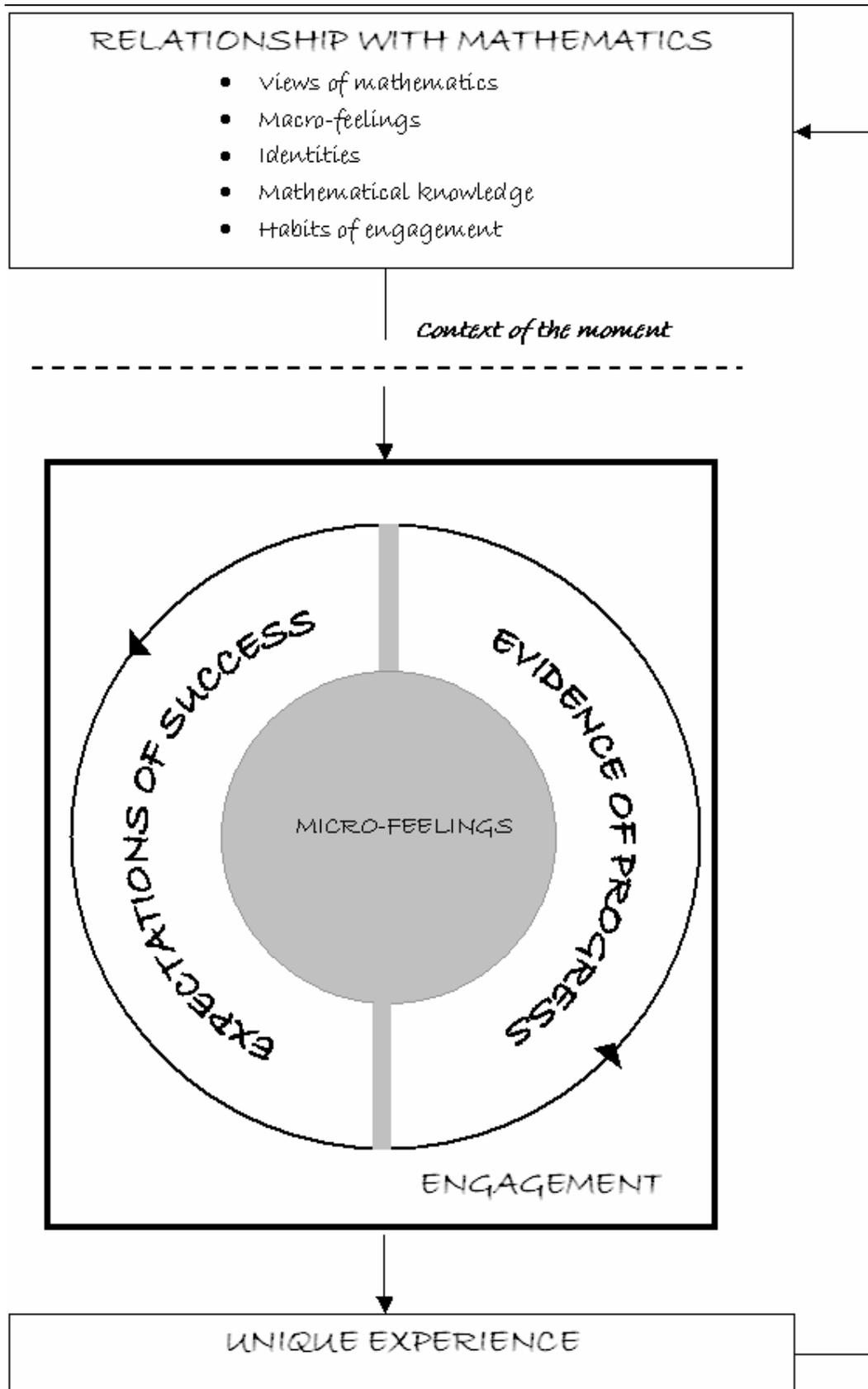


FIGURE 6.6 Changes in students' relationships with mathematics

Doing a mathematical task was situated in a particular context of the moment. Students' engagement in the mathematical task was determined by the complex negotiation between elements of their relationship with mathematics and the context at the moment. When students encountered a mathematical task, based on their relationship with mathematics, they interpreted both what they had been asked to do and the context of the moment. As students engaged in the task, they collected evidence of their progress. They experienced micro-feelings as they interpreted whether or not their progress met their expectations of success. The students' expectations and evidence of progress are represented within a circle to show that they surround a student's micro-feelings, and the arrows around this circle show that students' progress can alter expectations of success and vice versa.

The way the students engaged in the task contributed to their individual experiences and performances. The students interpreted the meaning of these experiences. The meaning derived from this negotiation, in turn, reinforced or altered components of their relationship. As Boaler and Greeno (2000) explain, learning mathematics is a constant process of negotiating meaning. This explanation captures the constant negotiation of the learning process of school mathematics.

## **6.5 Conclusion**

The students' mathematical journeys consisted of their changing relationships with mathematics and their learning experiences during their journey. Students' views about the subject, their macro-feelings, their identities, the habitual ways they engaged in mathematics, and their mathematical knowledge formed their relationship with mathematics. The majority of students disliked mathematics, and in this sense mathematics was a unique school subject. They became slowly negative about mathematics as they moved through secondary school as the classroom routines became more entrenched and the mathematics became more difficult and more boring. Students' dislike of mathematics was commonly associated with their view that they were not good at the subject and did not meet their own expectations or the expectations of the teacher, their parents, or classmates. These negative macro-feelings affected their engagement in mathematics overall, and their participation in the subject of mathematics. It also had implications for the seating arrangement in the classroom.

Students' relationships with mathematics operated on two levels. The students had overall views about the subject of mathematics, overall macro-feelings about mathematics, and

closely associated identities relating to how good they perceived they were at mathematics and how good they thought they should be. They also had habitual ways they engaged in the mathematics. These overall factors contributed to the students' interpretation of a particular mathematical situation. Students' views of mathematics led them to judge the task's importance and difficulty. Macro-feelings contributed to the micro-feelings they experienced during the task. Their identities led them to have expectations of being successful or not in the task. The ways they habitually engaged in mathematics, interacting with the other elements, affected their engagement in the task.

Through their choice of tasks, the routines of the mathematics class, where they allowed the students to sit, through their interactions with the students and through recognising and rewarding students, the mathematics teachers in this research helped to construct the social norms of the mathematics classroom. They controlled how social the mathematics was, influenced students' views of mathematics, and affected their mathematics feelings. The mathematics teachers were significant to the students and therefore potentially provided actual identities for them about their ability to do the mathematics. The teachers reinforced the class placement designated identities of the class, and had individual expectations of each student. They also highlighted gaps in students' sets of identities, and gave recognition to students considered to be in the top group in terms of mathematical ability. The students wanted the teachers to help them to feel better about mathematics by changing the routines of the mathematics classroom, and getting to know them better.

These data have been reported in this chapter as a class set of responses. The results have been generalised using examples from individual students to represent the class set of responses, with exceptions noted. Even though all of the students had views, feelings and ways of engagement in common with the rest of the class, every student's relationship with mathematics was unique. In Chapter Seven, I describe the mathematical journeys of individual students in a set of case studies.



# CHAPTER SEVEN: Students' Mathematical Journeys

As defined in Chapter One, a mathematical journey is a student's relationship with mathematics over time. Chapters Five and Six detailed the elements of the students' relationships with mathematics and described how these interacted with each other and changed over time. The 31 students had common qualities in their relationships with mathematics. Students were described as having a relationship with mathematics made up of their views of mathematics, mathematical knowledge, identities, macro-feelings, and their habits of engagement. As well as these similarities, each of the students had a unique journey through mathematics and this chapter describes four of these individual journeys. Colin, Philip, Robyn, and Ruth have been chosen for closer examination because their journeys highlighted different aspects of how students' relationships with mathematics changed over time.

During the research period Colin demonstrated very few negative affective responses to mathematics. He fully engaged in the mathematics and by examining his pathways of engagement, Colin's engagement skills can be identified and compared to other students. Colin highlights the need for mathematics education research to consider the impact of both positive and negative affect and the intensity of this affect. Colin's negative responses were significant because of their rarity and have an element of clarity about them. Colin is compared to other students in his class, but especially to Peter and Angela, other students considered to be in the top group in the class.

Philip performed at a level only slightly lower than Colin, but he was more typical of other students in the class in terms of his engagement. He was chosen because his mathematical journey included the impact of his parents on his set of identities. His parents voiced expectations about mathematics-related careers, mathematical courses chosen, and expectations of engagement and achievement.

Robyn's stories described large gaps between her designated and actual identities although she was fully engaged in the mathematics. Despite her hard work, she perceived that she rarely performed to her expectations. Robyn's journey was explored in this chapter to show

how her strong negative affective responses related to these gaps. Furthermore, similarly to others in the class, Robyn was intensely aware of her classmates' performance, she alluded to the idea of innate mathematical ability, and was dependent on the teacher's help.

Ruth provides a contrast to the other students presented in this chapter. Despite describing mathematics as her favourite subject in primary school, Ruth's engagement in mathematics was very low and she expressed negative feelings. During the research period, she showed marked changes in her designated identities. Ruth is presented here with some difficulty. Of all the students, there is the least data about her. Ruth's parents did not complete a parental questionnaire, nor did they initially give written permission for her to be involved, which meant she could not be included in the research in the first few weeks of Year 10. Many of her written responses are brief, she hid her exercise book when asked to hand it in, and she was removed from the research class half way through Year 10. Despite this, Ruth provided very rich responses in the interviews about her relationship with mathematics.

The students' mathematical journeys are mapped in terms of experiences that are significant to them, and in terms of their dynamic relationship with mathematics. The affective responses associated with their mathematical experiences are interpreted in terms of the gap between their actual and designated identities and their engagement in the mathematics.

Someone who had never met nor seen a photograph of the students drew the sketches used in this chapter. It is hoped that the sketches will remind the reader that this research is about adolescents who are the normal mix of vulnerability, angst, measured actions, carelessness, moodiness, and contradictions. Table 7.1, below, provides information as a reminder of the different classes and year levels of the students. The research period has been shaded. More information can be found in section 4.2.

**TABLE 7.1 Information about year level**

Year	Age	External qualifications	Class placement
Year 9	13-14		Achievement class
Year 10	14-15		Achievement class
Year 11	15-16	NCEA Level 1	MAT101 or MAT102

## 7.1 Colin



*Tall and angular, Colin had the loose-limbed carelessness of a teenage boy, too big already for the school desks. Colin's parents described him as imaginative and caring, with a good sense of humour and a strong sense of justice.*

**FIGURE 7.1** Colin

### 7.1.1 Prior to the research period

When Colin enrolled at the research school in Year 8, the teachers from the contributing school reported that Colin had sound work habits, a positive disposition, and was willing to please. At the enrolment interview, Colin was described as a “bright engaging boy” (Interviewer<sub>EnrolmentYear6</sub>). Colin described himself at this time as:

[I] expect to do the best that I can. ... I'm confident and social (Colin<sub>EnrolmentYear6</sub>).

With music and science, mathematics was noted as one of his general interests. His mathematics ability was considered to be excellent (PreviousSchool<sub>EnrolmentYear6</sub>) and, indeed, at his new school Colin very quickly established himself as having a particular flair for mathematics.

Colin is proving himself to be an excellent and highly motivated student of mathematics (MrPowell<sub>MathematicsReportYear7</sub>).

Colin has been a member of the extension maths group for the entire year, confirming his strength in this subject (MrThomas<sub>MathematicsReportYear8</sub>).

He won an Honours awards for mathematics at prize-giving in Year 7 and Year 8 and was recommended for the achievement class in Year 9.

Extension class! (The dean has underlined this three times). In class behaviour good! Sometimes tells others answers though (coz he knows 'em!). Gifted in many areas. Bright (Dean<sub>NotesYear8</sub>).

In Year 9 mathematics, in the PAT described in section 4.2, Colin's results were in the 99<sup>th</sup> percentile. This test positioned him at the top of both his class and students of his age nationally. Colin's mathematics teacher endorsed this positioning through her report writing and description of Colin's achievement and engagement in mathematics.

Colin is brilliant. He has never really been tested this year in class however he has stayed focussed and set his sights only on Excellence. His exam results were impressive. He is certainly deserving of the [Honours award at prize-giving] (MissHill<sub>MathematicsReportYear9</sub>).

When I had an interview with Colin's parents [last year] ... I said, 'I don't think I did anything for your son this year. The professor at the university extension group he attended would describe him as one of the most natural mathematicians he has ever, ever come across. Colin's amazing ... He should be doing university ... he could be the greatest scientist or the greatest mathematician ... so for him I'm amazed he just stays within the [behavioural] bounds (MissHill<sub>InterviewYear10</sub>).

Colin described his own perception of his ability and feelings about mathematics prior to the research period. He endorsed the view that his mathematics ability was high.

[In primary school] I learnt [maths] very quickly. I was soon faster than everyone else ... I'm clever. Early on I liked maths. I didn't find it boring ... other people might have found it boring. Since primary school I feel better about maths because I know more. I've always felt good about it. It makes me feel even better about it because I can do maths in my head ... I've always been better at subjects than other people but it's ... maths just helps me everywhere ... I was quite proud of being the best male mathematician [in Year 9]. I'm glad Angela didn't beat me (Colin<sub>InterviewYear10</sub>).

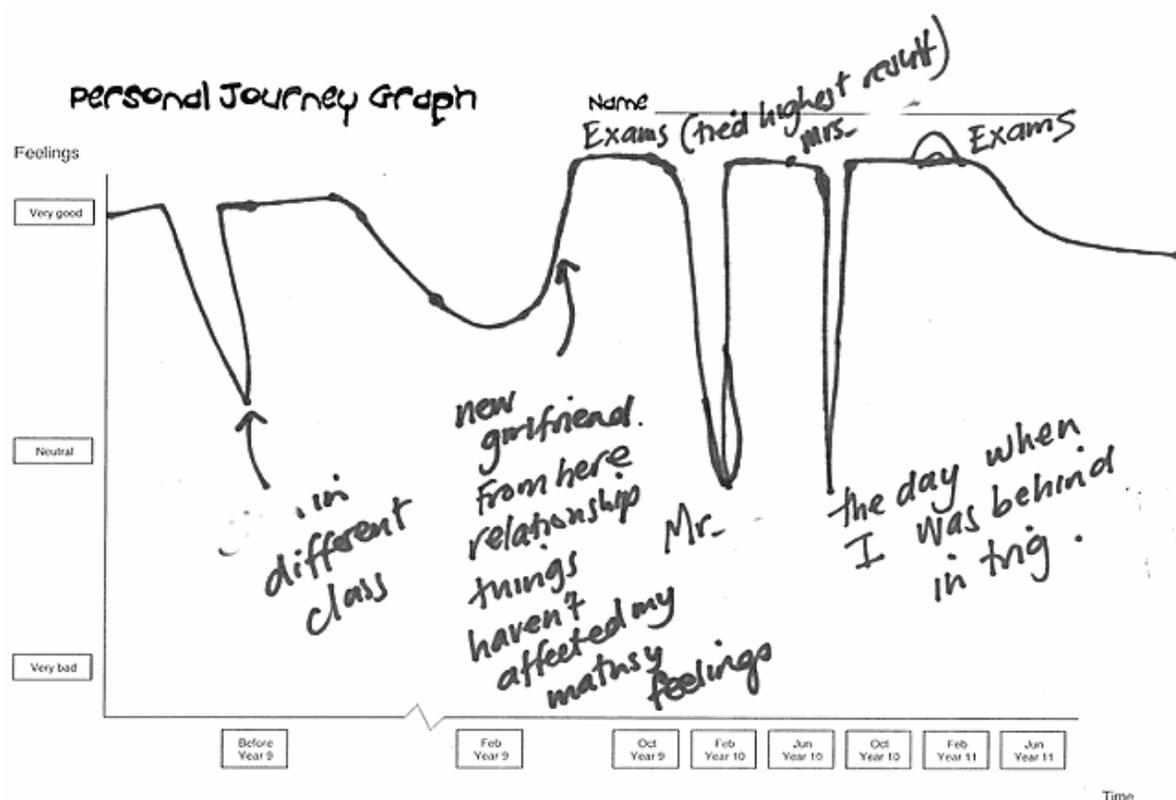
Even though mathematics and music were thought to be his particular strengths, Colin achieved well in his other subjects and was well regarded by all of his teachers as a good scholar with high engagement.

A class of students with Colin's attitude to work would be a teacher's dream. I have enjoyed teaching such a well-rounded pleasant student (MrJudd<sub>PhysicalEducationReportYear 9</sub>).

I have seldom seen such a fine student and young man rolled up into one. Colin has completed another year full of the excitement of learning, the discovery of new things and the soaring of the mind (MrMiller<sub>ScienceReportYear 9</sub>).

Before the research period began, Colin's stories indicated he had a high level of engagement in mathematics and an excellent level of mathematical knowledge. According to others, he had "stayed focussed", he was "highly motivated", his behaviour was good, and he had a good "attitude". Colin was aware that he "knew more" than the other students, and viewed mathematics as a subject that was, for him, quick to learn and certainly not boring. Colin considered mathematics to be an important subject. Mathematics helped him "everywhere", which presumably meant both at school and in his life outside of school.

Colin's set of designated identities meant that he expected to enjoy mathematics and to continuously learn more. Colin also expected to achieve at an Excellence Level in mathematics and perform in assessments and classroom tasks well above his classmates. He expected to do "the best" that he could. His reports, prizes, marks, and success with in-class tasks meant he always met and even exceeded his expectations. Each new, positive, learning experience and the recognition given resulted in further evidence of his ability, and contributed to his actual identities. He was the top mathematician in the school, a position he delighted in and was proud of. He could do mathematics in his head. Colin was "clever".



**FIGURE 7.2** Colin's personal journey graph

Colin's personal journey graph in Figure 7.2 showed his macro-feelings about mathematics. The names of his teacher and the name of a girl Colin was interested in have been erased. Before the start of Year 10, his macro-feelings about mathematics were generally very good. Interestingly, Colin perceived his romantic relationships to have an impact on his feelings about mathematics prior to the research period. Figure 7.2 shows a large downward spike before Year 9 when the girl Colin was interested in was placed in another class. This effect was perhaps inflated because of increased importance of social relationships to Colin in Year 11, when he drew the graph in a group situation.

### 7.1.2 Year 10

Table 7.2 summarises Colin's relationship with mathematics, as it was at the beginning of Year 10. This table shows the emphasis Colin placed on the different aspects of this relationship, so that it can be compared over time and compared to the relationship with mathematics of others. The elements included (in bold) were those that emerged from analysing the class set of data (section 6.4). The other words included in the table are either direct quotes from Colin or are his words paraphrased.

**TABLE 7.2 Colin's relationship with mathematics at the beginning of Year 10**

<b>View of mathematics</b>	Maths is important Maths is everywhere Maths is challenging Maths is exciting	
<b>Mathematical knowledge</b>	I know maths Intelligence is not magically acquired. It is an accumulation of knowledge.	
<b>Macro-feelings</b>	I love maths I love doing maths	
<b>Identities</b>	Actual	Designated
	I am great at maths I am top at maths I have a thing for maths	I should achieve at the top of the class I expect to enjoy and be enriched by maths
<b>Habits of engagement</b>	Maths makes me think. I think about it complicatedly. I love confusion I keep staring at it. I have the ability to go back to where I've started and correct myself.	

Seen in Table 7.2, Colin's relationship with mathematics at the beginning of Year 10 can be characterised by a strong view of what mathematics is and its importance. Colin had a mature and well-developed understanding of the nature of mathematics. His definition of mathematics was that it was "a language we use to evaluate situations and predict what will happen next" (Colin<sub>MetaphorsYear10</sub>). His metaphors for mathematics were all scientifically orientated.

Mathematics is like:

1. The universe. It is infinite and all encompassing.
2. An atom because it makes up everything.
3. The entire worldwide ecosystem. It fits together like a giant jigsaw puzzle.
4. The colour white. It is a blending of all the colours of light like all the elements of maths (Colin<sub>MetaphorsYear10</sub>).

Unlike the other students in the research class who restricted their view of mathematics to school mathematics, Colin discussed mathematics as a discipline not necessarily limited to the curriculum or institutional structure.

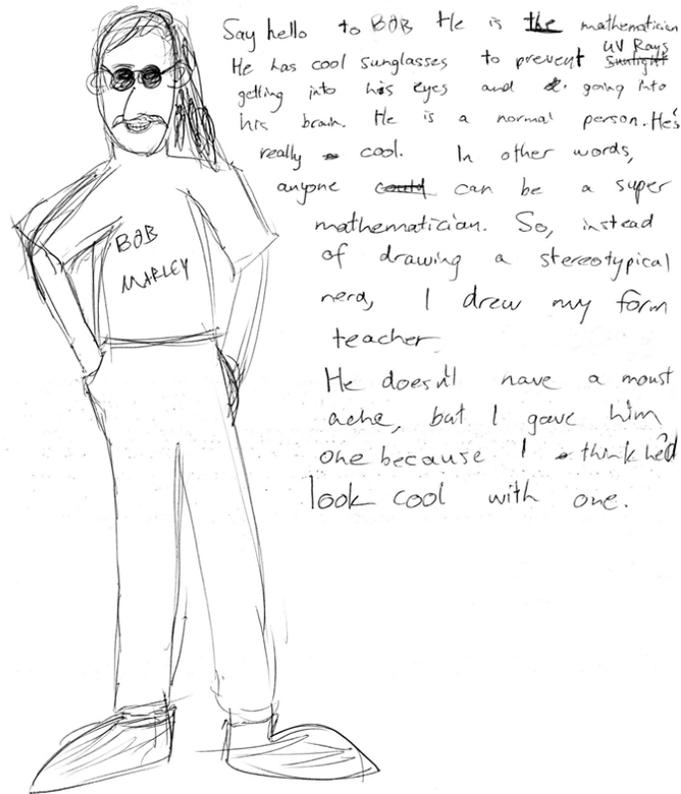
I don't see maths as a subject itself, I think of it more as a thing that goes everywhere (Colin<sub>InterviewYear10</sub>).

Colin valued mathematics highly as a discipline for life-long learning (Colin<sub>AutobiographyYear10</sub>). When asked to draw a mathematician, Colin drew the trendy man with dreadlocks seen in Figure 7.3 below. Colin's text is difficult to read, and so is replicated here.

Say hello to Bob. He is the mathematician. He has cool sunglasses to prevent UV rays getting into his eyes and going into his brain. He is a normal person. He's really cool. In other words, anyone can be a super mathematician. So, instead of drawing a stereotypical nerd, I drew my form teacher. He doesn't have a moustache, but I gave him one because I think he'd look cool with one (Colin<sub>MathematicianYear10</sub>).

Colin's drawing of a mathematician implies that Colin believed that being a mathematician was a realistic and accepted role in society. A mathematician is a "normal person" and could be "cool". He did not distance himself from the possibility of one day becoming a mathematician or being considered a mathematician currently. The majority of students felt that school mathematics represented the mathematics practised by mathematicians and therefore, with their drawings of mathematicians, seemed to be rejecting both mathematicians and the subject of mathematics. Indeed, Colin felt that there was little social stigma attached to being good at mathematics and went on to say the following:

No one really cares about whether you're a nerd or not anymore ... people are my friends regardless. It's great. I love it. I'm lucky to be born at this time ... nerds don't really exist as much any more (Colin<sub>InterviewYear10</sub>).



**FIGURE 7.3** Colin's drawing of a mathematician

Colin's relationship with mathematics also had emphasis on his confidence in his knowledge and his love of the subject (see Table 7.2). Colin enjoyed the subject both because of its nature *and* because of his perception of his ability in it compared to his classmates. In Year 10, Colin continued to love mathematics, thought it was fun, and was excited by it (Colin<sub>AutobiographyYear10</sub>). His enthusiasm and willingness to discuss all things mathematical was highlighted in his Year 10 interview, where Colin discussed at length the mathematics in the Hitch-Hikers Guide to the Galaxy (Adams, 1979), the theory of relativity, and how the construction toy Kynex had helped him to learn the concepts of factors and multiples. In Year 10, Colin's designated identities were similar to those of the year before and related to expectations of enjoyment, enrichment, and achievement.

Colin's actual identities demonstrated his views about his own mathematics ability. He enjoyed being known as a top mathematician and knew that it was unique to be interested in mathematics in this way. He felt he had a different relationship to mathematics compared to his classmates.

Maths is a thing for me ... I just feel like I have a thing for maths (Colin<sub>InterviewYear10</sub>).

I always like being better ... than other people ... I like the feeling of knowing that no-one usually understands ... but I kind of do (Colin<sub>InterviewYear10</sub>).

Peter and Angela's designated identities also included expectations relating to being in the top group, but Colin's feelings about mathematics were different to theirs. Peter did not enjoy mathematics (section 6.1.1), thought it was boring, and engaged in the assigned tasks to finish them as quickly as possible.

If maths were food, I would eat [it] quickly to get it over and done with it (Peter<sub>MetaphorsYear10</sub>).

Colin enjoyed mathematics because of his first-in-class positioning, but also because of the nature of the subject and his expectations of enrichment. On the other hand, Angela enjoyed mathematics because she was successful in the subject in comparison with her classmates, and because being good at it enabled her to gain entry into her future career.

I'm quite good at maths so therefore I like it (Angela<sub>EndofYear10</sub>).

I don't have mathematical discussion. I don't really feel like I'm missing out. Mathematical discussions don't really ... interest me (Angela<sub>InterviewYear10</sub>).

I am happy and excited when I understand a new mathematics concept because it's an achievement and it will help with future tests (Angela<sub>GroupInterviewYear11</sub>).



FIGURE 7.4 Peter's (on the left) and Angela's drawings of mathematicians

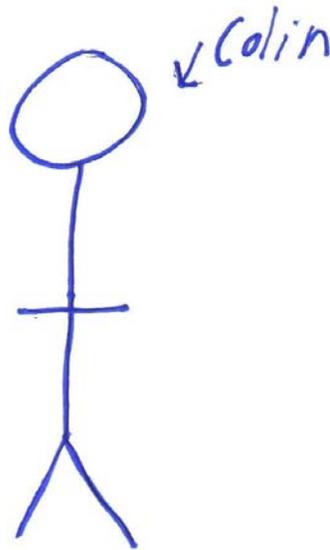
Interestingly Peter believed that a mathematician was a nerd and Angela's view of a mathematician was of an older male, seen in Figure 7.4. These drawings seem to somewhat contradict Colin's assessment that nerds no longer existed and anyone could be a mathematician. Indeed, Peter and Angela's drawings of mathematicians suggested that they distanced themselves from their concept of a mathematician.

Colin had little difficulty in achieving to a level consistent with his expectations. Colin defined doing well in an assessment as achieving an Excellence grade, getting a score of 100% or performing better than the others in the top group (Colin<sub>InterviewYear10</sub>). Colin described mathematics as not difficult in general, did not find any topic difficult to do, and always understood what was taught in class (Colin<sub>AutobiographyYear10</sub>). Colin also received a number of reinforcements from classmates and teachers to believe in himself as an excellent mathematician, frequent and strongly reifying stories that contributed to his set of actual mathematics identities. Colin was often discussed by his classmates and frequently connected to the top group of mathematicians in the class. Indeed, 16 of his classmates discussed him without prompting on 39 separate occasions during the research period. This is significantly different from the other students in the class. Angela and Peter, other students in the top group, were also frequently mentioned. Angela's name was mentioned unsolicited by 12 students in 24 separate discussions and 12 students mentioned Peter's name in 18 discussions. Very few other students were mentioned.

Colin is top of maths in the school (Alasdair<sub>InterviewYear10</sub>).

Everyone wants to be in my group when we do maths things ... it's like (Colin calls out) Peter, Colin, Angela, come over here (Colin<sub>InterviewYear10</sub>).

Paul, when asked to draw a mathematician, drew a stick figure, which he labelled 'Colin', thus equating Colin to a mathematician.



**FIGURE 7.5 Paul's drawing of a mathematician**

The ways that the mathematics teachers contributed to students' views about their ability has been described in detail in section 6.2.1. During Year 10, the teachers assumed Colin would be included as part of mathematics competition teams and external mathematics enrichment activities, entering him before others were considered (Researcher<sub>ObservationYear10</sub>). During class discussions, Colin frequently put his hand up to answer questions, and this was well received by the teachers. Furthermore, the teachers openly highlighted Colin's work, broadcast his assessment results (Colin<sub>ObservationYear10</sub>), and directed students needing help to Colin.

I like it when people ask me things. I could be a teacher when I grow up ... and even when someone else might [be able to help] ... I feel like they think I'm just the person who knows it really (Colin<sub>InterviewYear10</sub>).

Colin had a role in class as being the top mathematician. The expectations relating to this role were part of his set of designated identities. The students in the top group were perceived to achieve highly, engage fully, and be confident and enthusiastic.

I think it's the way Peter, Angela and Colin ... it's the way they do it. They're confident with it ... like they don't talk and they concentrate real well (Jason<sub>InterviewYear10</sub>).

I don't feel [like I'm in the top group] because I'm not really enthusiastic (Paul<sub>InterviewYear10</sub>).

As part of this top group, Colin was expected to do extremely well in, or be the 'best' in assessments, answer the teachers' questions, help others, work consistently, be organised, behave well, and always understand everything in class. Students often used the progress of the top students as a benchmark to assess their own results and progress.

I always want to see what the top people got or you sort of look over every now and then to see what they're up to (Connor<sub>InterviewYear10</sub>).

At the beginning of Year 10, Colin was meeting his designated identities. In other words, Colin's experiences in mathematics provided evidence that he was meeting his expectations of enrichment, enjoyment, achievement, and positioning. As his actual identities met his designated identities, he continued to experience very positive affect. He never worried about the subject in general, never suffered from test anxiety, and felt great about his academic achievement (Colin<sub>AutobiographyYear10</sub>). Furthermore, he thoroughly enjoyed the subject (see Figure 7.2).

Colin began Year 10 with continued high engagement in mathematics. During the initial observations, he always had with him the necessary mathematics books and equipment and he completed the set tasks efficiently, often engaging in mathematical discussions with classmates about the tasks or helping others to understand the tasks. For the difficult starter problem described in section 6.1.2, Colin explored the problem initially incorrectly (see the right hand side of Figure 7.6 below) and then approached the problem from another angle after the teacher gave a further explanation, circling the final answer heavily. His engagement in this problem was continuous until he had understood the answer, well after the rest of the class had moved on to textbook work.

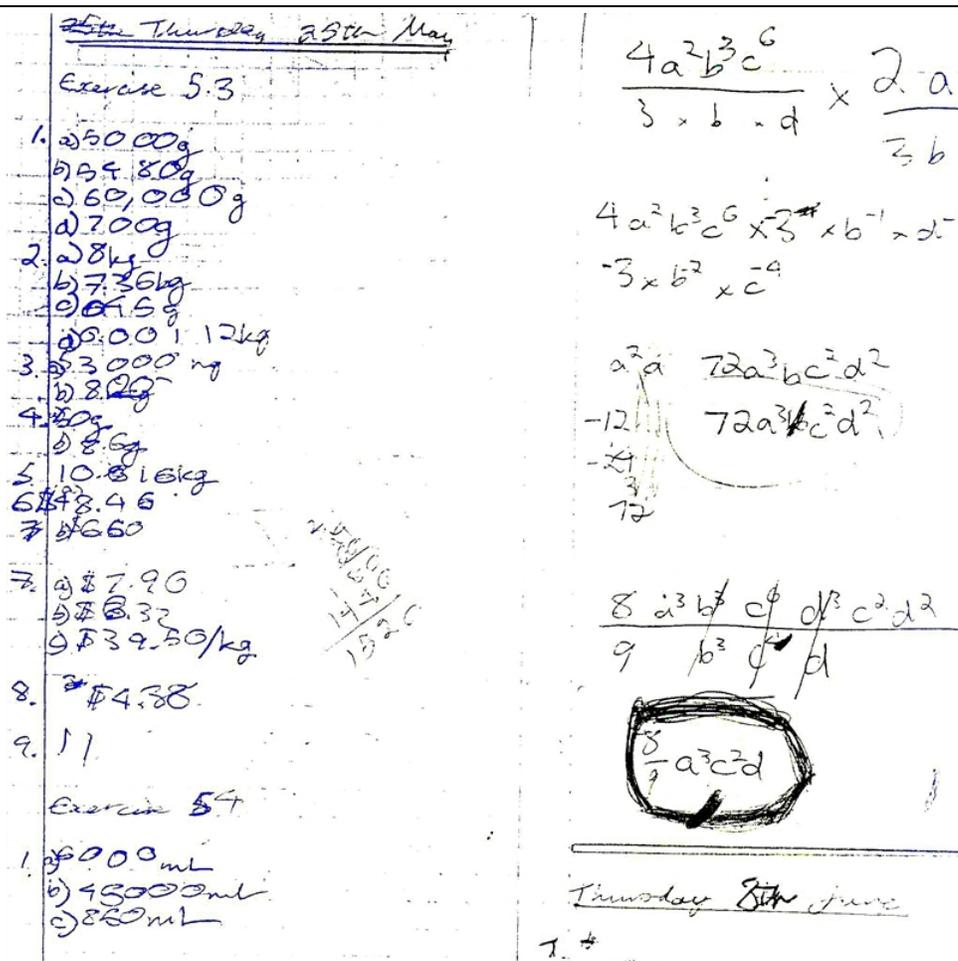


FIGURE 7.6 Colin's exercise book

The way Colin responded to this difficult mathematical task was typical of the way he typically engaged in a mathematical task, thus exemplifying his pathway of engagement. Colin usually worked on mathematics problems until he had an answer which was correct and which he understood. He expected confusion, enjoyed being challenged during mathematical activity, and was patient when he did not immediately understand something, knowing that, eventually, with more thought or new mathematical knowledge, he would (see Table 7.2). He saw each new mathematical task as an opportunity to learn more, and he engaged in it more deeply than others.

I love doing stuff with infinity ... I love doing that because it confuses. You know all those paradoxes that philosophers have that made them go insane ... the people who make complicated things that really confuse people. For some reason [they] just make sense. If I can't do something ... that makes me just keep staring at it until I get it. [If I still don't get it], I keep staring at it. Maybe I'm looking at it the wrong angle and ... There's no problem that I haven't found out the answer to ... I have a big book at

home full of brain teasers ... and you learn how they work eventually and some I just don't get and I come back and I'm like oh I know what that word means now so ... or I know the answer to that now. That makes sense (Colin<sub>InterviewYear10</sub>).

I think about it really complicatedly ... usually when I see a problem I think about it 20 times as complicated as it actually is ... and I love it because it's actually challenging stuff (Colin<sub>InterviewYear10</sub>).

[Maths] makes me think. I like thinking. I spend a lot of time doing it. I think about maths things (Colin<sub>InterviewYear10</sub>).

Colin thought about his own learning and engagement processes and compared these to those of other people.

I do think about it more complicatedly than Angela does sometimes [but] she's a better learner and more motivated person than I am sometimes (Colin<sub>InterviewYear10</sub>).

[My sister] thinks about [problems] different to me. She gets it differently and I guess I have an ability when I've learnt something I can go back to where I started with and correct myself. [I] take that for granted when [I] learn. It made her stuck at a certain level (Colin<sub>InterviewYear10</sub>).

Colin felt that his accumulation of mathematical knowledge over a school year was because of the way he engaged in the mathematics. He linked "knowing" with mathematical intelligence.

When people are talking about growing up ... [they] think when you grow up you'll magically become really intelligent but you've seen people who are grown up and they're not. I realised that a couple of months ago ... [People] feel like [they] just automatically know a year's worth of stuff after a year ... but ... I do [know a year's worth of stuff] ... it's a cumulative learning. You've learnt so many things in a year and you look back on the year before and you think hmmm (Colin<sub>InterviewYear10</sub>).

During Year 10, there were periods of time where there were changes in Colin's level of engagement in mathematics and he experienced some negative emotions and feelings when he did not fulfil the expectations created by his designated identities. Colin's engagement in the mathematics significantly lowered when Mr Murray took over the class for one term. During

this term, Colin often talked socially for most of the mathematics period and did little work. Indeed, he rarely completed the initial work assigned to him. At one stage I asked him to hand in his exercise book and he did so reluctantly.

I didn't do [much work that term]. You might have found there wasn't much in my book (Colin<sub>InterviewYear10</sub>).

Colin's lack of engagement in the mathematics that term was consistent with many of the other students in the classroom (see Tracey's comment in section 5.1), a consistency unusual for Colin. During this term, Peter, rather than Colin, was positioned first in the class in standardised national testing. Mr Murray, although acknowledging he "liked Colin", viewed Peter as the top mathematician (Mr Murray<sub>FeedbackYear10</sub>) and it was Peter that was the focus of the extension work (section 6.2.3). Colin was not receiving the same acknowledgement from his mathematics teacher that he was used to and this perhaps contributed to his change in engagement.

Colin's personal journey graph, drawn the following year and seen in Figure 7.2, reflected his feelings about mathematics during that term. He commented that Mr Murray was the cause of the first downward spike in Year 10. He described the spike as bad (it is actually just below neutral) but felt it did not affect his macro-feelings about mathematics.

That [downward spike] doesn't really count because we didn't do anything so how can I be able to do something if I don't actually try and doing anything (Colin<sub>GroupInterviewYear11</sub>).

During that term, Colin did not withhold effort to preserve his view in his ability. Rather, he did not put effort in because of what the class as a whole was doing. His view in his ability remained unshaken. This is somewhat in contrast with other research that talks about students' efforts being associated with their view of their ability.

If you withhold effort and do poorly, you can still think highly of your ability, and you can preserve the belief that you could have done well had you applied yourself. If you somehow happen to do well anyway, then this is the supreme verification of your intelligence (Dweck, 1999, p. 41).

When Mrs Brown returned to teach the class Colin's feelings about school mathematics and his engagement in the mathematics returned to what they had been previously. Yet, it became more difficult as Year 10 continued for Colin to be enriched by the subject of mathematics. In Year 9, Colin seemed to be celebrated for his unique interest in mathematics. However, in Year 10, Colin's main teacher Mrs Brown was uncomfortable with Colin's strong need for individual mathematical learning because of her lack of confidence in her own mathematical content knowledge.

Kids like Colin, they think outside the square. I couldn't possibly be put in a situation where I can't answer questions. It happens a lot in this class because there's always that possibility that ... Colin will come up with something. I have to have it prepared so I know exactly what I'm going to do and I can look at all the possibilities ... all the things that might come up. He comes up with bizarre things that kind of throw me. He does it because that's the way he thinks. Colin likes learning ... he just takes in everything that he can (Mrs Brown<sub>InterviewYear10</sub>).

Indeed, Colin thought Mrs Brown was a "good teacher" but not into "random tangents", which he enjoyed in mathematics.

Mrs Brown probably thinks I'm a bit weird ... and my thinking strange ... and how I say really random things during class sometimes ... I ask the most complicated questions ... sometimes she can't even answer them. I like asking questions that make teachers think. It's always nice asking a question you know the answer to, but you're not really meant to do that (Colin<sub>InterviewYear10</sub>).

For Colin, sometimes school mathematics did not meet his need for mathematical enrichment.

When stuff is really repetitive it motivates me to actually do my work ... perhaps if I can get all of these done I can have some free time at the end of the period and think about music or other maths (Colin<sub>InterviewYear10</sub>).

As Year 10 went on, Colin became more committed to music and social activities. Colin's parents were aware that his focus was changing and a gap was opening between what was expected of him, what was happening in the classroom, and what he was achieving.

His interest in maths extension opportunities has decreased in direct relation to the increase in his music interest/social activities (ColinFather<sub>QuestionnaireYear10</sub>).

Over the past two years his energy for maths has decreased as he concentrated more on his music (ColinMother<sub>QuestionnaireYear10</sub>).

[My parents] don't want to push me, but they end up pushing me because I've got Excellences all the time and they get a bit worried when I don't get an Excellence, I just get a Merit (Colin<sub>InterviewYear10</sub>).

In Year 10, Colin had several absences because of his music commitments. For example, during Term Three, he had 13 absences out of 34 mathematics periods, missing around 40% of the lessons for one unit. It also seemed his feelings were changing.

Colin can ... be a little negative at times and does miss a lot of class because of his music (Mrs Brown<sub>ReportAugustYear10</sub>).

During the unit where he missed 40% of the lessons, Colin returned to mathematics after time away to discover he did not have the mathematical knowledge of his classmates. The day Colin "was behind" accounted for the second downward spike in Colin's personal journey graph in Year 10 (see Figure 7.2).

I am used to telling others what to do, not the other way around. [I was absent for] two weeks. When I ... came back I felt very behind because I didn't know a lot of the stuff (Colin<sub>InterviewYear10</sub>).

I felt denied ... I was panicking. It was very dramatic. I remember that day very vividly (Colin<sub>GroupInterviewYear11</sub>).

During one observation later in Year 10, I saw Colin struggling with a mathematics problem and then close the book with a resounding bang. He seemed flustered and defensive when I asked him if he wanted to discuss the problem, and told me the problem was "not the focus of the day's lesson" (Colin<sub>ObservationYear10</sub>). The mathematics teacher overheard this exchange and later laughed and said that Colin was not used to being asked if he wanted help.

Colin reacted visibly when he got marks back and, differently to earlier in the year, he was defensive and secretive about what they were (Researcher<sub>ObservationYear10</sub>). Asked to endorse these observations, Colin explained he got a bit down in class when he did not do well in an assessment. In other words, he experienced negative affect when his achievement did not

meet his expectations. This was highlighted when he was asked what his worst mathematics experience was.

Whenever I only get one wrong. I feel like [I] can't get 100% in a test. I shouldn't be making silly mistakes. I check it like three times. I wish I could like start school again and then get 100% in every test ... and then be able to say I got 100% in every test I ever did at school (Colin<sub>InterviewYear10</sub>).

At the end of the year, Colin studied for the mathematics examination for “two minutes by quickly looking at notes” (Colin<sub>EndofYear10</sub>) and got mostly Merit grades for the different sections of the assessment. Significantly, because of his placing in the class for the examination, he did not get an Honours award at the prize-giving. These awards were important to Colin. He remembered what he and several of his classmates got in all their subjects over several years (Colin<sub>InterviewYear10</sub>). He said that mathematics was his worst subject in the examinations.

The exams were worse [than I was expecting]. I wasn't focussing on the exam. I was studying for Japanese (Colin<sub>EndofYear10</sub>).

When we get results back and we're like comparing them and stuff like ... At end of year I was surprised with Colin. I think he got like ... I did better than him. I got more Excellences. [He felt] probably a bit stink (Connor<sub>GroupInterviewYear11</sub>).

Interestingly, Colin's personal journey graph, drawn in Year 11, showed that his examinations in Year 10 resulted in positive feelings, contradictory to his results and feelings at the time. Reviewing the audiotape of the drawing session. Colin said, “I've forgotten to add in the exams. I can't remember. I must have been good”. Colin then added a small positive spike to account for the examinations in Year 10, which can be seen in Figure 7.2.

Although Colin experienced some negative micro-feelings in mathematics during Year 10, and his engagement was not consistent, these incidents should be kept in perspective. At the end of Year 10, Colin remained a highly motivated and engaged member of the class, and his macro-feelings about the subject overall remained very positive.

### 7.1.3 Year 11

In Year 11, Colin was placed into MAT101. According to his reports and the teacher's feedback (MrPowell<sub>FeedbackYear11</sub>), he had a good level of mathematical knowledge and worked conscientiously, enthusiastically, and with commitment.

Colin has worked extremely conscientiously and with a pleasing enthusiasm. He brings a high level of commitment to his work and has developed a sound understanding of the principles covered so far. He is a pleasure to teach (MrPowell<sub>ReportJuneYear11</sub>).

Yet, Colin's enjoyment in school mathematics had decreased since the beginning of Year 10 (see personal journey graph in section 7.1.1). He did not seem so enthusiastic about mathematics in written feedback and during interviews or observations. MAT101 was made up of people from the achievement class and other students who had achieved a certain standard in the mathematics examination at the end of Year 10. Colin found the change of class difficult. Like the other members of the top group, Colin had been especially competitive with Peter and Angela in Year 10 (section 6.2.3). He knew all of their results in mathematics for the last few years, knew the prizes they had won, and thought about their learning processes. In Year 11, Colin missed the competition that he had enjoyed the previous year (Colin<sub>FeedbackYear11</sub>). He was now in a different class from Angela and Katrina, and was frustrated with Peter's negativity about mathematics. He felt that the classroom atmosphere and the behaviour of some of the students were detrimental to his freedom to pursue mathematics and have enriching mathematical discussions.

I don't like this class as much because there is a stronger general negative vibe about maths [than last year]. The [other] side of the room is loud [and] I find Peter's negativity towards maths and lack of motivation annoying (Colin<sub>AutobiographyYear11</sub>).

Peter says mean things about maths. I feel frustrated because there are heaps of reasons why maths is useful (Colin<sub>AutobiographyYear11</sub>).

Sitting beside Colin is weird because he loves maths and I cannot understand why. Even when we're not supposed to ... he's just sitting there doing maths (Peter<sub>GroupInterviewYear11</sub>).

Before Year 11, Colin's designated identities were to do with expectations of enjoyment, enrichment, and ease of achievement compared to his classmates. In Year 11, there was a sense that Colin seemed slightly frustrated with school mathematics.

You need to know maths to be a maths teacher. [Lola: what?!] It's not always the case. Some teachers are just staying two pages ahead of everybody (Colin<sub>GroupInterviewYear11</sub>).

I want to do Calculus but I can't [this year] (Colin<sub>GroupInterviewYear11</sub>).

In Year 11, Colin was now very specific about his career goals. He wanted to be a film composer and mathematics played a lesser role. Rather than talking about his expectations of excitement and enrichment, his designated identities seemed to become focussed on achievement only. Colin continued to have high expectations of his success in mathematics. Unfortunately, he also had evidence that he had gaps between his actual and designated identities.

[This year] I want to get every single thing that I can to the highest ... I want to get all the credits I can to Excellence level. Maybe. That would be nice. But I've already got a Merit this year so I haven't [done that] (Colin<sub>GroupInterviewYear11</sub>).

Colin's experiences in Year 11, meant that he was now nervous when walking into mathematics class, when working on homework, and studying for a test (Colin<sub>AutobiographyYear11</sub>). Colin seemed cautious about mathematics, perhaps not taking his marks for granted. At the end of Year 11, in his NCEA examinations, although Colin achieved all of the possible credits for each of the papers in mathematics, out of the nine possible Excellence grades, Colin received three. This was in contrast to Music and Japanese where he was awarded Excellence grades for all his papers (Colin<sub>NCEAYear11</sub>). Previously to these grades coming out, Colin received an Honours award for mathematics, with Angela, Peter and Katrina, at the Year 11 prize-giving. He enrolled in mathematics in Year 12, when it became non-compulsory.

### **7.1.4 Colin's relationship with mathematics**

Colin's designated identities at the beginning of the research were about enjoyment, enrichment and performance. Colin loved mathematics because of his enjoyment of the field of mathematics itself *and* because he enjoyed his status as a top mathematician and being able

to do mathematics better than others. Using Dweck's (1999) conceptualisation of students' goals (section 2.3), Colin could be described as both performance and mastery oriented. He was performance oriented because he was interested in his achievement, competitive with his classmates, and enjoyed recognition for being the best mathematician. On the other hand, he also sought to master the content because of his enjoyment of the subject. He was curious and wanted to explore mathematics.

Colin viewed mathematics as more than a school subject. At the beginning of the research period, mathematics was a discipline that was part of his life and would continue to be in the future. When he drew a mathematician, unlike many of the other students who drew stereotypical nerds (section 5.2.2 and section 7.1.2), Colin depicted a mathematician as a normal person who could be cool. According to Picker and Berry's (2000) research, this type of image is positive for a student's mathematical learning. In this way, it seemed, Colin did not dissociate himself from a mathematician – continuing to learn mathematics was both attractive and viable to him.

Colin associated a person's intelligence with their mathematical knowledge. He disputed that a person could become "magically more intelligent" and disputed that they "automatically" knew more. Rather, Colin thought his intelligence was his present level of knowledge, which accumulated as he engaged in and learnt more mathematics. In this sense, he had an incremental view of intelligence (Dweck, 1999), believing intelligence could be cultivated through learning. The more he did mathematics, the more he learnt. Colin described himself as clever, mathematics being "his thing" and "knowing more" than the other students in the class because of the way he engaged in the mathematics.

When analysing Colin's engagement in the mathematics compared to other students, a set of engagement skills emerged, which contributed to his habitual pathway of engagement. Table 7.3 summarises the engagement skills that emerged from analysing the class set of data. Colin could be described as having good *engagement skills*. The term 'engagement skills', rather than 'habits of engagement' is used because a skill implies something that has been actively fostered rather than simply a habit that has developed over time. Colin actively fostered his engagement skills by reflecting on them.

Colin usually engaged fully because he saw each mathematical situation as an opportunity to increase his mathematical knowledge. Using DeBellis and Goldin's (2006) terms, Colin

demonstrated high mathematical integrity and mathematical intimacy. In other words, Colin was emotionally involved in the mathematics and he demonstrated vigour in his search for mathematical truth and understanding. Many of his classmates sought instrumental understanding. They wanted to get the correct answer as quickly as possible using a procedure they had learnt off by heart, without understanding why that procedure worked (section 5.2.3). Instead, Colin sought to understand the mathematics relationally. He sought more than just the correct answer to a task. He sought understanding, by thinking about the task more “complicatedly” because of its potential to add to his knowledge, and because he enjoyed the experience.

**TABLE 7.3 Engagement skills**

Perseverance	The skill of continuing to do a mathematical task, despite experiencing difficulty.
Integrity	A commitment to searching for mathematical truth and understanding – searching for more than the correct answer.
Intimacy	Deep emotional engagement with mathematics.
Independence	The skill of solving problems autonomously.
Concentration	The skill of remaining focussed on the mathematics, and continuing engagement despite disruption.
Utilisation of micro-feelings	The skill of being resilient to negative micro-feelings, and instead using them as a signal to persevere or change strategy.
Cooperation	The skill of discussing mathematical with others, to solve the tasks cooperatively, and to ask for help as a strategy, rather than as a form of disengagement or dependence on others.
Reflection	Being self-aware. Reflecting on own and others' engagement.

When Colin came across a difficult problem, he anticipated that he would experience micro-feelings such as confusion, slight anxiety, as well as curiosity. He was not only resilient to these micro-feelings, but he was able to utilise them. Micro-feelings were affordances, rather than constraints, and a signal to persevere or change strategy such as going back to the beginning or discussing the mathematics with others. Furthermore, Colin thought about his processes of engagement. He described himself as good at what he termed “meta-cognition” (Colin<sub>InterviewYear10</sub>). Colin was aware that the way he engaged in the mathematics differentiated him from his sister and other students and contributed to his greater level of mathematical knowledge. Like the students in Sullivan et al.'s (2006) research, Colin's

classmates were not cognitively aware to the same level as he was. They did not seem aware of the processes of solving problems, and were generally unable to articulate in any detail the difficulties they were experiencing. They were not resilient to their micro-feelings and did not actively utilise them to support their mathematics, often giving up at the first hurdle. In Malmivuori's (2006) words, they regulated their affective responses automatically rather than actively. They responded to their feelings without reflection. Colin had high self-awareness, control of his responses, and high personal agency. Consequently, he could be described as actively regulating his affective responses (Malmivuori, 2006).

Colin was different in many ways to other students in the 'top group'. For example, Angela's designated identities were concerned with learning mathematics for achievement and recognition. She understood that to perform in mathematics she needed to have mastered mathematics and so, like Colin, Angela showed high mathematical integrity in her engagement. In contrast, she did not display the emotional engagement with mathematics – the mathematical intimacy that Colin displayed. She was different from Colin because she valued doing well in the subject more than enjoying and valuing the subject itself. Her learning was predominately ritualised. In other words, her need for mathematical fluency was like an entrance ticket to her chosen career with no particular value of its own (Sfard & Prusak, 2005a).

Angela continued to achieve to her expectations of performance throughout the research period. However, there was a sense that if she was unable to meet these designated identities, there were likely to be more significant consequences for her than for Colin. She was more vulnerable than Colin because she was reliant on her positioning and her teacher's praise and directly connected these with achievement. Sullivan et al. (2006) call this type of student a "praise junkie" (p. 97) and warn that these students may be vulnerable if the praise stopped. Certainly, Colin's feelings about mathematics changed when Peter got 'his' attention from Mr Murray. Angela, thrived in the assessment-driven NCEA year, but there is a sense that her continuing participation in mathematics is entirely reliant on her need for a mathematics qualification. There is a risk that, as the mathematics becomes more difficult, if Angela does not continue to achieve at such a high level in mathematics she may experience increasingly negative feelings about the subject. Her participation choices may be affected once she has achieved the minimum requirements of mathematics for her chosen career. Despite this, Angela was more resistant to negative micro-feelings and issues of routines and boredom than Peter, who did not continue with mathematics after Year 11 (section 6.2.1), because of her

strong designated identities relating to mastery and performance and his intense feelings of boredom.

Until mid-Year 10, there was no discernable gap between Colin's actual and designated identities. He was enjoying mathematics, achieving at the top of the class and fulfilling his role of being a top mathematician. He had positive macro-feelings about the mathematics, a high level of mathematical knowledge, and the way he engaged in the mathematics meant this knowledge was accumulating.

At the same time, Colin was not immune to the social features of his learning environment. He experienced difficulty in achieving his designated identities when there were changes in teacher, the classroom environment, or there were changes in his own focus. When Colin experienced difficulty or failed to achieve his designated identities relating to achievement, like students with a mastery orientation (Dweck, 1999), he was fairly resilient.

His failures to meet his expectations did not affect his actual identities – his view of how good he was at mathematics. Indeed, he attributed his failures to other factors, such as focussing on another subject instead of studying for the end of year exam. They did affect his designated identities because he decreased what he expected of himself. In this way, Colin closed the gap between his actual and designated identities.

On the other hand, his intensely felt micro-feelings during this time related to his position in the class. Colin's perception of his parents' expectations, and the classmates and teachers' continuing expectations of Colin within the classroom contributed to the tension he experienced. Dweck's (1999) research on students who are labelled as gifted described similar issues. She explains that, when students are labelled as gifted, they may become over-concerned with justifying that label.

They ... begin to react more poorly to setbacks, worrying that mistakes, confusions, or failures mean that they don't deserve the coveted label. If being gifted makes them special, then losing the label may mean to them that they are 'ordinary' and somehow less worthy (Dweck, 1999, p. 125).

Even though Colin's macro-feelings about the discipline of mathematics remained generally positive, Colin's expectations relating to enjoyment and enrichment were not always met and his macro-feelings about school mathematics (if not the discipline of mathematics) began to

diminish slightly (see Figure 7.2). He was not encouraged to think outside the square and wanted to finish the tasks quickly to think about “other maths”. This seemed to continue somewhat into Year 11 where there was a change of class and fewer opportunities for him to discuss the mathematics. Indeed, in Year 11, Colin rarely talked about his excitement of mathematics, perhaps because of the assessment-oriented environment of that year. School mathematics was no longer exciting. Although his designated identities related to performance remained important, his expectations relating to enjoyment and enrichment and his designated identities relating to school mathematics seemed to diminish.

Despite this, Colin continued to engage in the mathematics more fully than his classmates and performed well showing that, although he was not immune to changes, he was mostly resilient to the changes. If he continued to remain resilient to the lack of enrichment in school mathematics, Colin may continue to participate in the field, in some form, throughout his lifetime.

In summary, Colin’s relationship with mathematics can be characterised by a love of mathematics, his belief in the importance of mathematics, a high level of mathematical knowledge, a view that he was good at mathematics, and expectations of achievement, enrichment, and enjoyment. Colin also had well-developed engagement skills. Colin’s relationship with mathematics changed over two years in that his macro-feelings about the subject diminished slightly and his expectations of enjoyment and enrichment lessened to enable him to close the gap between his actual and designated identities. Colin however, remained fairly resilient to these changes and continued to generally enjoy mathematics, engage fully, increase his mathematical knowledge, and perform well.

## 7.2 Philip



*Philip is tall with a wide smile. He wears his uniform casually, and occasionally flicks his long hair away from his eyes in a practised motion. One of Philip's teachers described him as a real boy's boy, and the sportiest boy in the class.*

**FIGURE 7.7 Philip**

### 7.2.1 Prior to the research period

In Year 6, Philip's parents described him at the school's admission interview as an "independent ... energetic worker [with an] inquiring mind" (Parents<sub>QuestionnaireYear6</sub>). This view of Philip is somewhat consistent with Philip's teachers' view of him prior to the research period, though his reports across all subjects occasionally mention statements such as "Philip is now working better" and "displaying some silliness from time to time". In mathematics, according to his school reports, Philip seemed to have high engagement and achievement.

Philip loves maths challenges [and has] great application (PreviousSchool<sub>Enrolment2001</sub>).

Philip has worked consistently hard all year, taking every lesson seriously and putting in every effort in order to succeed. Philip enjoys maths and is confident working in all aspects of the subject (MrThomas<sub>MathematicsReportYear7</sub>).

Philip drew his personal journey graph in Year 11, and this is shown in Figure 7.8, below. Again, his teachers' names have been erased. Two mathematical experiences prior to the research period had resonance for Philip resulting in higher points in the graph.

In Year 2, I aced a problem-solving question. I've still got that test in the drawer!

(Philip<sub>GroupInterviewYear11</sub>).

Philip rated this experience as giving him the most positive feelings about maths he had ever had. Indeed, it is the only time his feelings about mathematics, according to his personal journey graph, could be considered “very good”.

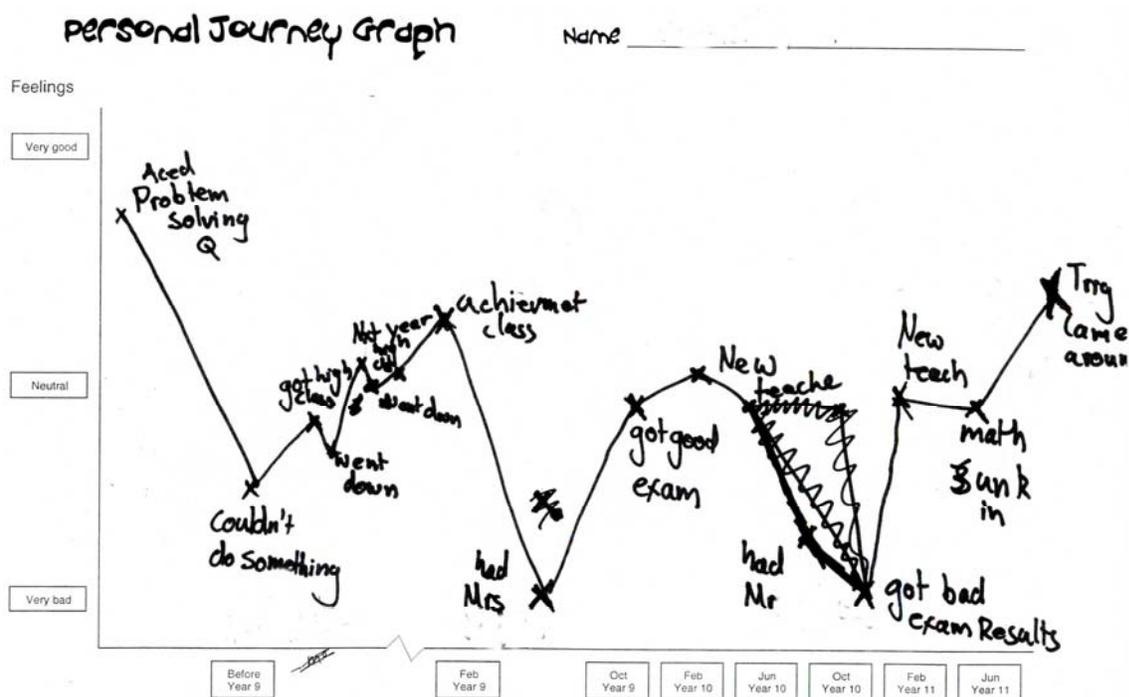


FIGURE 7.8 Philip's personal journey graph

Philip viewed a further incident as a low point prior to the research period, commenting on the personal journey graph that he “couldn’t do something”. This micro-feeling Philip experienced was significant enough to remember five years later. This memory establishes that being able to do the mathematics, especially in comparison to his classmates, was important to Philip.

That was in Year 6 when we had to find the missing numbers and I just couldn't figure it out. And then the teacher marked someone else [correct] in front of me and I got really annoyed with that (Philip<sub>GroupInterviewYear11</sub>).

Being streamed into and out of the extension mathematics classes in Years 7 and 8 because of his achievement on pre-tests were also significant events in Philip's mathematical journey and affected his overall feelings about mathematics. In Year 9, Philip was placed in the

achievement class. The second high point in Philip's personal journey graph was when he was selected for the achievement class. He writes "Next year high class" and "achievement class".

Very organised. Begins work quickly. Competitive. Recommended for the [achievement] class (Dean<sub>NotesYear8</sub>).

Philip, prior to the research period, seemed to be competent at mathematics according to evidence such as class placement, prizes, and examination marks. His main Year 9 teacher described him as an able mathematician who it had been "a pleasure to work with" (Philip<sub>MissHillReportYear9</sub>).

I enjoyed teaching Philip because Philip gives you lots of feedback and lots of positive feedback too like even if he's finding a particular exercise not that stimulating he was able to work in a very positive way (MissHill<sub>InterviewYear10</sub>).

Like his classmates, Philip experienced some difficulty with Mr Toomey's class in Year 9.

The worst maths experience I had was ... Mr Toomey just put ... an equation on the board and he told us to do it and no explanation at all ... tons of people were complaining. ... I think he just had high expectations of us ... the achievement class. ... We haven't been taught that kind of algebra before (Philip<sub>InterviewYear10</sub>).

[A good maths teacher] explain[s] it well. Mr Toomey wasn't good like that ... he just expected us to know it (Philip<sub>GroupInterviewYear11</sub>).

The fact that many of his classmates also found the class difficult perhaps helped him feel better about it. Similar to Susan's description of this class in section 6.2.2, Philip seemed to have a sense of collective justification, frequently using the word "us". He said, "tons of people were complaining", about the expectations of the achievement class. Philip certainly experienced negative micro-feelings that may have contributed to his macro-feelings about mathematics and his views about teachers. In his personal journey graph, Philip refers to his mathematics teachers four times, either naming his teacher or scribbling on the graph "new teach" and "new teache".

Prior to the research period, Philip seemed to need external acknowledgement of his achievement to feel good about his mathematics. His enjoyment of mathematics also seemed

conditional on his teacher. Philip's macro-feelings about mathematics became more generally negative in Year 9, as can be seen in Figure 7.8. Only good examination marks at the end of the year accompanied by a Progress at prize-giving improved his feelings about the subject. From these brief glimpses, it is not clear how his engagement was influenced by his feelings.

### 7.2.2 Year 10

**TABLE 7.4 Philip's relationship with mathematics at the beginning of Year 10**

<b>View of mathematics</b>	Maths is solving problems using rules Maths is old but useful. Maths is not important for the career I want.	
<b>Mathematical knowledge</b>	I get the knowledge if I need it. I know this. There are too many rules that don't work.	
<b>Macro-feelings</b>	I don't really have any feelings. It's just there. Once it got a little more complicated, I got a little less interested.	
<b>Identities</b>	Actual	Designated
	I'm capable. I have potential. I usually get the work.	I expect to do maths quickly, easily, while having fun. I expect to do better than most of the other people. Dad wants me to be a high achiever.
<b>Habits of engagement</b>	I slack off when I can. I don't talk about maths. I don't ask for help. I'll try it and if I can't do it, I'll quit.	

Philip's relationship with mathematics at the beginning of Year 10, shown in Table 7.4, shows a somewhat different view of mathematics to Colin and different feelings, identities and particularly, different habits of engagement.

At the beginning of Year 10, Philip viewed mathematics as “working with numbers [to] solve problems to get from point A to B” (Philip<sub>MetaphorYear10</sub>). Mathematics was about getting the answers to mathematical tasks using rules. It was a subject that should be able to be done quickly and easily. He also described mathematics to be like classical music – old but still useful (Philip<sub>MetaphorYear10</sub>).

Philip's father was very influential on Philip, and thus a significant narrator and important source of Philip's designated identities. Indeed, Philip's father was the ultimate addressee of Philip's efforts.

Dad wants me to be the high achiever ... I don't want to be a bum (Philip<sub>InterviewYear10</sub>).

In New Zealand 'being a bum' means someone without a job or career and with few aspirations of getting one. Philip's career plans had changed over the course of his school years, perhaps to meet his father's expectations. When he was ten, Philip wanted to be a doctor (Philip<sub>EnrolmentYear6</sub>). Four years later, Philip's plans had changed.

My dream is to become an All Black [rugby player] and also a rock star, and then become a physiotherapist and own my own clinic and then hopefully open an institute for free learning for music (Philip<sub>InterviewYear10</sub>).

He described the limited way mathematics fitted into those plans.

If I had a choice I would not take maths because in the career I want to take it looks non-important (Philip<sub>QuestionnaireYear10</sub>),

Philip expected to come across mathematics only in a financial way.

I'll probably only see maths in currency (Philip<sub>InterviewYear10</sub>).

Philip and his Dad seemed to disagree over his future career.

All my three sons have shown strengths in the sciences fields. ... Philip is considering his career plans at the moment, and is looking at science-based plans, so will give maths a serious consideration! (Philip<sub>FatherQuestionnaireYear10</sub>).

When asked to draw a mathematician, Philip drew an alien with an enlarged head wearing a buttoned shirt, a calculator in its pocket, tight shorts and socks pulled up (see Figure 7.9). Although there was no accompanying explanation, and he may not have taken the exercise seriously it seems that, unlike Colin, Philip distanced himself from the concept of a mathematician. The idea of becoming one was not an attractive prospect.



**FIGURE 7.9 Philip's drawing of a mathematician**

Philip described his macro-feelings about mathematics as becoming more negative as he moved through school. He experienced little nervousness about the subject at the beginning of the year (Philip<sub>AutobiographyYear10</sub>). He felt very good about his academic achievement in mathematics at the start of Year 10 (see Table 7.4), and believed he was achieving the marks he was capable of. Indeed, there was some evidence, which indicated Philip was a capable mathematician. In the standardised assessment described in Chapter Four, Philip scored in the 91<sup>st</sup> percentile for his age level across New Zealand. Yet, he also had increasingly frequent feelings of boredom when he was “not having fun and couldn't be bothered” (Philip<sub>QuestionnaireYear10</sub>). Furthermore, as the mathematics increased in difficulty Philip talked about having to think rather than just doing.

[I enjoyed the] early stuff ... but once it got a little more complicated, I got a little less interested ... it's ... like the more harder, the more you think ... making you think (Philip<sub>InterviewYear10</sub>).

You need to do something with maths but it could be harder or you don't know what to do (Philip<sub>MetaphorYear10</sub>).

There are too many rules that don't work like they are needed (Philip<sub>InterviewYear10</sub>).

When Philip came across a hard problem he described spending “ages trying to figure it out” (Philip<sub>InterviewYear10</sub>) but would skip it if he could not. He got frustrated and annoyed, and often

disengaged (Philip<sub>InterviewYear10</sub>). He did not ask the teacher for help and only rarely asked classmates because “they don’t know the answer either” (Philip<sub>InterviewYear10</sub>). Apart from occasionally helping his classmates with their mathematics, often by giving them the answers without explanations, Philip was never observed to have a mathematical discussion during Year 10.

We just don’t talk about maths. I really haven’t ever had a deep discussion about maths in my life (Philip<sub>InterviewYear10</sub>).

Many of Philip’s designated identities during Year 10 were about being able to do mathematics *at least as well as his classmates* and many of his positive emotions surrounded these identities. When he compared his mathematics to his classmates, Philip felt “successful, smart, and superior” (Philip<sub>MetaphorYear10</sub>). Philip was competitive with others in the class and measured his own perceptions of his ability against others.

I’m capable. There are some people that obviously can’t do stuff (Philip<sub>InterviewYear10</sub>).

Despite his apparent confidence in his mathematical ability, Philip did not feel he belonged in the top group of mathematicians in the class because of his ‘slackness’. Philip, whose mathematics achievement was only a little lower than the students in this group, distanced himself because of how he perceived his own behaviour.

I feel like there are ... people like Colin and Angela that just get down to it. I probably don’t feel like [I’m in the top group] because I just slack off when I can (Philip<sub>InterviewYear10</sub>).

I think [the teachers] can see my potential but they can see me slack off too much (Philip<sub>InterviewYear10</sub>).

Other students too did not recognise Philip to be in the top group of students despite his selection for a mathematics competition.

We got Philip especially so he could run fast, so me Angela and Colin did all the questions ... oh Philip did one (Katrina<sub>InterviewYear10</sub>).

I just had to run around. That’s why I was in the [group] (Philip<sub>InterviewYear10</sub>).

When there is a gap between how he wanted to see himself and how he actually saw himself, Philip experienced frustration and worry. Philip expected to be able to do the mathematics, but he had little intrinsic motivation to engage at more than a superficial level (as described in section 5.1). When Philip got evidence that he was not able to do the mathematics, he sometimes justified this by rationalising that his classmates could not do the task either, or he argued the teacher did not explain it properly or did not prevent his poor behaviour. When the relief teacher had trouble controlling the class, for example, Philip said he would be worried if that happened all the time.

I [usually] do my work. Last term I probably didn't but hardly anyone did. I actually thought it was quite slack [of the teacher]. I was kind of happy I didn't do the work but I don't actually like being in a class where there's too much mayhem. I was kind of worried because [of] my Dad (Philip<sub>InterviewYear10</sub>).

Philip's father's view was that his three sons, including Philip, had little problem with mathematics and any issues Philip had with it were to do with him needing to work harder. This comment comes after Philip's father had received the mid-year report from school.

Philip needs to apply himself more to [maths] and he would find it easier!  
(PhilipFather<sub>QuestionnaireYear10</sub>).

[My father] probably thinks I'm slack, but I do think he does know that I do get the knowledge when I need it (Philip<sub>InterviewYear10</sub>).

Philip's father's expectations of his success seems to come without support at home in terms of help with the mathematics, and is coupled with a strong opinion that maths teachers are ineffective, if not detrimental to a student's success in mathematics.

No [I can't help Philip with his homework]. Maths sucks! And I can't do it! ... [I] hated [maths]!! [At] 3rd form level the maths teacher was diabolical ... All teaching depends on the teacher! and how they impart information as long as minds are eager to learn!! ... My only memories of school are how I disliked maths!! Even after 30+ years! Maths teachers are as useful as paper boats! (Father<sub>ParentQuestionnaireYear10</sub>).

It was not surprising perhaps that Philip's macro-feelings about mathematics were strongly affected by his teacher as seen in his personal journey graph in Figure 7.8. Philip seemed to view the teacher as the person responsible for the control of his behaviour, and the provider of

tasks he could do quickly and easily. When Philip experienced difficulty or boredom, Philip echoed his father's views of teachers, by blaming the teacher for this difficulty. Furthermore he did not use them as a potential resource when he needed help.

As Year 10 went on, Philip did not engage highly in the mathematics and attributed it to the fact that he usually understood the work easily. Philip also wanted to have fun and be social.

Because I usually get the work and so that's probably why I get bored and be like oh I know this and just distract others that don't know it ... I just slack off when I can. I can't be bothered. Also I don't want to go insane over too much work  
(Philip<sub>InterviewYear10</sub>).

I just didn't really want to do it [last year] so I actually did less work and that's basically it (Philip<sub>GroupInterviewYear11</sub>).

These comments endorsed observations of Philip in Year 10. He was often late getting out his equipment and starting the mathematics lesson compared to his classmates. He seemed to do the answers to the assigned task as close to the end of the assigned time as he could, sometimes doing an exercise quickly during the time the teacher took to sweep around the classroom checking work or in the teacher-talk time while a new concept was being introduced to the class. Philip's exercise book from Year 10 was dog-eared and dirty. His work sometimes started half way down the page, few of the pages were ruled up and the work was often undated and unnumbered. The notes were muddled in with the exercises and often unfinished (Observation<sub>Year10</sub>).

Indeed, Philip was described by his teacher as very social in class, engaging in off-task talk for a larger proportion of the time that he worked on mathematics.

Philip won't shut up ... oh my goodness he drives me crazy (laughs affectionately and then sighs) he's more of the class clown ... and that's his way ... I often have to pull him up for inappropriate behaviour just being silly when he shouldn't be and talking when he should be doing his work ... Easily distracted. Very easily distracting ... he could set the whole class up (Mrs Brown<sub>InterviewYear10</sub>).

Philip studied for only 40 minutes for the end of year examination, yet he talked about needing to do well because of his father's expectations.

If I don't get the results he wants I'll get screamed at which is not pleasant  
(Philip<sub>QuestionnaireYear10</sub>).

He had a difficult time in the examination and it was harder than he expected.

When you're in an exam it feels really stressful. My hair was falling out in the  
[Year10] end of year exams [Connor: Were you pulling it out?] No. I thought I was  
going to fail man. [Naomi: That surprises me because you seem really relaxed in  
class]. Yeah. It's because I don't study. I don't study. I was thinking about it and then  
they came up and I was oh, I'll be fine. They'll be as easy as last year. But they were  
harder and I think crap! (Philip<sub>GroupInterviewYear11</sub>).

Philip received mixed results in the examination with one Excellence and one Not Achieved  
in the five standards assessed. The teacher held Philip accountable for these results.

He is often distracted in class and more focus would ensure more pleasing results ... if  
you want to do well next year in Mathematics then you need to focus more on the job  
at hand and less on what is going on around you (Mrs Brown<sub>ReportDecemberYear10</sub>).

The exam results and the report sent home were strong indicators that Philip was not meeting  
the expectations of his father. For Philip, they would have been strongly reifying actual  
identities and evidence of a gap between his identities relating to his father's expectations.  
There is no evidence about how Philip felt these assessment results compared to his  
classmates. As shown by his personal journey graph in Figure 7.8 this was a critical incident.  
The intensely negative micro-feelings affected Philip's macro-feelings about mathematics as a  
whole.

### 7.2.3 Year 11

In Year 11, Philip described a change in his behaviour in class. He engaged more in the  
mathematics, attributing it partly to the teacher's direct access to his parents and partly to his  
father's expectations of his success.

The teacher that we have now, she's [a] friend of my parents and so I knew I couldn't  
slack off because I knew I'd get in trouble (Philip<sub>GroupInterviewYear11</sub>).

I'm nervous before our results come back. ... I'm worried when [I]'ve got to tell [my] results to [my] father (Philip<sub>GroupInterviewYear11</sub>).

His teacher's comments to me and in his school reports also seemed to endorse this change.

Happy-go-lucky, a little slack at times; aiming for health science but cruising along at Achieved level until recently. Tends to talk in class and so he is not getting as much done as he could. Very scruffy note taking. He keeps up with work and shows promise (Miss Cotton<sub>FeedbackMayYear11</sub>).

Philip has had consistent success this year, achieving in every topic. He can be a little too social in class, but usually manages to complete his work despite this (Miss Cotton<sub>ReportJuneYear11</sub>).

Philip has continued to achieve in class. He takes an interest in his work and likes to discuss difficult problems with others. He asks questions when he needs to and revises well for assessments. Philip is often social as he works. If he develops the capacity for silent work, he will get a lot more done (Miss Cotton<sub>ReportSeptemberYear11</sub>).

Perhaps leading to an improvement in his engagement, there was a new awareness in Philip that his achievement in mathematics was related to the effort that he put in. In May, he wrote that he was not achieving generally what he was capable of in mathematics and had begun to worry about the subject of mathematics (Philip<sub>AutobiographyYear11</sub>). When asked why he thought he was not achieving his potential he wrote

I'm just not working hard enough or I'm not (Philip has crossed out the words 'try' and 'paying') studying (Philip<sub>AutobiographyYear11</sub>).

The class Philip was placed in also may have had an effect on Philip's engagement. Philip, in a discussion with Connor, stressed the importance of being in MAT101 rather than MAT102 (section 4.2) in terms of the classmates in the class being more focussed on their work.

Connor: Some of the kids this year are a bit different because they have to work ... not muck around.

Philip: Yeah, that's why you can choose MAT101 because you know that [naughty] people will go to MAT102.

Connor: Yeah doing MAT101 Maths you're going to get a good class. Good people (PhilipConnorGroupInterviewYear11).

Furthermore, in Year 11, Philip was in a class without any of the top group of mathematicians, and consequently he was recognised as a good mathematician. In Year 11, his expectations of being able to do the mathematics in comparison to his classmates were often met.

[You feel real happy] when you're getting it and no one else is getting it (Philip laughs) ... Sometimes I feel joyous (both other boys splutter with laughter) ... joyous because when I got Merit I was skiting so high and Alasdair didn't like me. He was like 'shut up Philip'. [Joyous is] when you're getting results and when you find out you're top of the class (PhilipGroupInterviewYear11).

His macro-feelings about mathematics began to steadily improve (see Figure 7.8). By the end of Year 11, after external examinations, Philip had achieved all of the available standards, receiving 34 credits. Three of those standards were at a Merit level and one, internal standard, was at an Excellence level. He received no award for mathematics at prize-giving. At the end of Year 11, Philip selected mathematics, biology, physics, and chemistry for his option subjects in Year 12, suggesting that he had re-focussed on health sciences, the career choice of his father.

#### **7.2.4 Philip's relationships with mathematics**

Compared to Colin, Philip did not have strong views about the nature of mathematics or its importance. Like many of his classmates he had an instrumental view of mathematics (section 5.2.1). He learnt mathematics – gained mathematical knowledge – by expanding the set of rules. Even though Philip acknowledged mathematics was somewhat useful, especially for certain careers, he had little interest in mathematics as a discipline, and certainly distanced himself from being a mathematician. He only discussed mathematics in terms of experiencing school mathematics.

Philip was “slack” in mathematics class. He was chatty, social, and distracted. Philip had less effective engagement skills than Colin. He usually only superficially engaged in a mathematical task. He rarely persevered when he experienced difficulty, he was unprepared to think too much and, unlike Colin, he did not demonstrate either mathematical integrity or

intimacy in his pathways of engagement. Colin was resilient to potentially negative micro-feelings, instead utilising them to enhance his engagement in the mathematics. Philip did not have the same awareness of the potential of negative micro-feelings, instead linking confusion and difficulty with a need to think and therefore seeing them as something to be avoided. When Philip experienced difficulty in a problem, he tried for a while using his set of rules that formed his mathematical knowledge, and then skipped it without looking back. He seemed to experience difficulty with questions that did not directly use the rules. He worked independently because he did not talk about mathematics with his mates. He used neither his teacher nor his classmates as a resource and he was unable to ask his parents for help.

Philip's designated identities at the start of Year 10 were to do with being able to do the mathematics quickly and easily while having fun. He wanted his life to be easy, fun, social, and active without thought or consequences. Philip also expected to do well compared to his classmates, and achieve the results his father expected of him, and in this sense he was performance oriented. He enjoyed mathematics less as it became more complicated. He experienced tension because he had assumed that if he completed the required work "quickly, easily and while having fun" then he would fulfil his achievement-related designated identities of doing well in comparison to his classmates and meeting his father's expectations. He was like the 'bright' students described by Dweck (1999).

Much of the work bright students receive is relatively easy for them and they are usually able to avoid confronting difficulty ... Sooner or later everyone confronts highly challenging work (Dweck, 1999, p. 13).

As the mathematics got more complex, Philip's designated identities got increasingly more difficult to achieve, and he experienced increasingly negative macro-feelings about mathematics. His boredom could have been a factor in this. In Csikszentmihalyi's (1988), research, students who described themselves as bored most of the time, disliked mathematics and were on their way to giving up on the subject, even though their ability appeared to be at least as high as the group which did not describe themselves as bored.

Philip's view of his intelligence is difficult to establish, although he does describe himself as "clever". Sullivan et al. (2006) found in their research high achieving students who had an entity view of intelligence. As these students did not think they would get better by trying,

Sullivan et al. (2006) suggested these students would be “vulnerable when they begin to experience difficulties in learning mathematics” (p. 89). Philip seems somewhat different to these students, because he did seem to appreciate the importance of engagement. He talked about his potential, which was unmet because of his “slackness”, or he accounted for his difficulties by blaming the teacher. He believed he knew why he was not meeting his expectations, and did not attribute it to his ability in mathematics.

In Year 11, Philip’s designated identities associated with his father dominated his social needs and provided his motivation. Philip’s engagement in the mathematics was no longer superficial. Although still social, he usually completed the work, and revised well. When working on a mathematical task, he asked for help when he needed it, and discussed the task with his classmates. By discussing the mathematics more, he perhaps was able to have some of his social needs met. Philip showed an awareness of the connection between engagement and achievement and his engagement skills began to improve. He was able to better meet his designated identities associated with achievement and therefore he was able to close the gap between his actual and designated identities. He began to enjoy aspects of success, feeling joyous when he came top of the class. This is somewhat similar to Colin, who, as he became more focussed on other areas of interest in Year 10, also experienced a gap between his expectations and his achievement. The gap between Colin’s expectations and what was occurring in the mathematics classroom quickly closed because of his enjoyment of mathematics and his strong engagement skills. For many of the other students, however, the gap was too wide and difficult to close and they did not develop their engagement skills.

## 7.3 Robyn



*Robyn is a beautiful young woman with dark, glossy hair and a huge smile. She is well presented, wearing her uniform neatly and her hair tied back. Robyn's parents described her as a gifted and conscientious girl with a really great attitude.*

**FIGURE 7.10** Robyn

### 7.3.1 Prior to the research period

In Robyn's enrolment interview, she was described as gifted by her parents and "really conscientious" (Robyn<sub>EnrolmentYear6</sub>). Robyn's conscientiousness continued to be a theme of her school mathematics reports.

Robyn has worked extremely conscientiously and with a pleasing enthusiasm (MrsWest<sub>ReportYear7</sub>).

Other early reports from other subjects included expressions such as "her conduct ... has been an example to others" (Robyn<sub>EnglishReportYear7</sub>), and "mature and sensible approach" (Robyn<sub>PEReportYear7</sub>).

During Years 7 and 8, for each unit of work in mathematics, a pre-test was given and students were streamed into different classes according to the results of this assessment. Other subjects were not streamed. Robyn was not placed in the extension mathematics group during those

years. Despite this, by the end of Year 8, Robyn was deemed to have good mathematical knowledge.

Robyn has developed some excellent mental strategies. Very good basic facts knowledge. Needs extension in Year 9 (Dean<sub>NotesYear8</sub>).

In Year 9, Robyn was placed in the achievement class. According to her teacher, Robyn questioned her class placement in this class.

Robyn ... would say [in Year 9] ... I can't do maths I don't know why I'm in this class because I can't do maths but the fact was that they had these ... people who can do maths who'll talk about it with them. They do homework [together] they discuss problems ... if you watch Robyn and Angela and Joanna ... it's the perfect pair mentoring (MissHill<sub>InterviewYear10</sub>).

I'm not sure [about this class] ... I think maybe I underestimate how good I actually am. My teachers think I'm better at my work than I really think I am. I know [last year] Miss Hill really enjoyed teaching me because she said ... I'm a good girl and all this (Robyn<sub>InterviewYear10</sub>).

Her class placements in Years 7 and 8 seemed to factor into her feelings.

Mr Toomey was putting this stuff up on the overhead all the time and we had no idea what to do. He expected us to know it from Year 8. It was like for goodness sake aargh ... not all of us were in the high class [in Year 8]. There was about two or three who knew what to do and everyone else was sitting going 'What?' (Robyn<sub>InterviewYear10</sub>).

Robyn's parents said that she found "problem solving difficult at times right throughout her schooling" (RobynMum<sub>QuestionnaireYear10</sub>). Robyn endorsed that she had experienced difficulty with problem solving, by which she meant word problems and problems that required several steps. Reflecting on her early years in mathematics, Robyn "vividly remember[ed] crying over a maths problem in primary school" (Robyn<sub>PersonalJourneyGraphYear11</sub>).

I think it started at primary school when I started with problem solving I was like aarrgh, because it took me so long to work through it. By the time I'm just starting to

get the hang of it everyone else has got the answers. I get quite frustrated with problem solving (Robyn<sub>InterviewYear10</sub>).

Robyn enjoyed topics she found easy and that she was able to do.

I quite enjoy Statistics and Graphs and things like that. I think from an early age I found that quite easy maybe and I found I could do it ... I was good at it whereas if I started off a bit unsure about it and [the feeling] just kept on going I told myself ... I never felt I was good at it (Robyn<sub>InterviewYear10</sub>).

Despite Robyn's questioning of her class placement, she achieved at a high level in the Year 9 examination, gaining two Excellences out of the five strands and was awarded a Progress prize in mathematics at the prize-giving on the basis of these results. Miss Hill later said Robyn "blew her away" in these examinations, achieving at a level much higher than expected (MissHill<sub>InterviewYear10</sub>).

Robyn has had a great year. Her exam results were brilliant and I am very proud of her. She is to be congratulated on her Certificate of Progress (MissHill<sub>ReportYear9</sub>).

Robyn's examination results were very good and somewhat consistent with her excellent results in other subjects in Year 9 (Robyn<sub>ReportsYear9</sub>). Interestingly, Robyn did not discuss these examination results when she was interviewed the following year and they did not feature on her personal journey graph, shown in Figure 7.12.

Robyn was highly engaged in mathematics prior to the research period, working conscientiously, discussing the mathematics with her classmates and teachers, asking questions, and completing her homework. Her micro-feelings during mathematics were conditional on her finding the task easy and being able to do it. Her questioning of her class placement was associated with a lack of confidence with being able to meet the expectations that came with the placement. She recognised that most of the people in that class had been in the extension maths groups in Years 7 and 8. She perhaps assumed they had learned different content and felt lacking in comparison to them.

### 7.3.2 Year 10

**TABLE 7.5 Robyn's relationship with mathematics at the beginning of Year 10**

<b>View of mathematics</b>	Maths is all about following a set of definite steps to get an answer. Mathematics is controlling. Maths is needed, apparently.	
<b>Mathematical knowledge</b>	I know how to do the easy steps. I need definite steps of how to do it that I keep going over	
<b>Macro-feelings</b>	I do not enjoy maths.	
<b>Identities</b>	Actual	Designated
	I am not excellent at maths. Maths is not my strength I feel like I can't achieve I feel inferior I feel stupid.	I need to achieve as well as my other subjects. I need to achieve well, comparatively to those in the top group. I should be doing good.
<b>Habits of engagement</b>	Try my hardest Keep going over it. Ask for help. Get someone to explain it to me.	

Robyn's relationship with mathematics at the beginning of Year 10, summarised in Table 7.5, is very different from Colin and Philip's. Robyn had different views of maths, less confidence in her ability, and was reliant on help in her habits of engagement.

Robyn defined mathematics in Year 10 as the process of "using numbers and mathematical words that result in only one specific answer" (Robyn<sub>MetaphorsYear10</sub>). Her metaphors for mathematics gave a sense of both her views about the nature of mathematics and her macro-feelings about the subject. Robyn seems to see mathematics as an entity with overwhelming and continual authority and power.

A pilot in control of a huge system.

Blue, moody and dark.

A tiger. Menacing, but a great creature.

A big old mansion but no one home. Beautiful on the outside but cold, though there might be hidden treasures.

A slow song on replay – orchestral. You hate it or love it ... continual

(Robyn<sub>MetaphorsYear10</sub>).

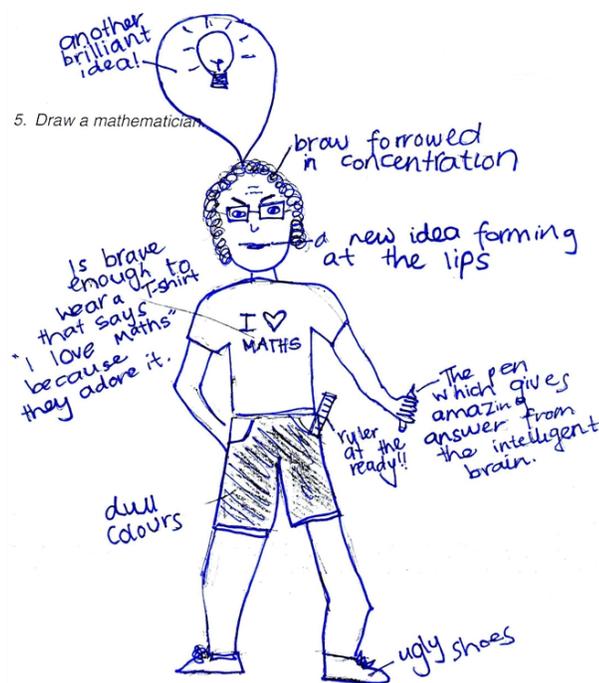
Robyn understood, to some extent, that mathematics was deemed to be an important subject, though like others in her class she was perhaps unconvinced.

Yes, it's really important to take maths for my career, though I wouldn't really enjoy it

(Robyn<sub>AutobiographyYear10</sub>).

Maths apparently is needed in most career options so you will always come across it during your daily life (Robyn<sub>MetaphorsYear10</sub>).

Robyn's drawing of a mathematician (seen in Figure 7.11 below) is somewhat gender-neutral and, although she does not distance herself as much as Philip from the idea of being a mathematician, there are some indications that being a mathematician is not in her present or future goals. Robyn's mathematician has tightly curled hair, wears dull colours, and ugly shoes. He or she needs to be "brave enough" to advertise with their t-shirt that they love mathematics.



**FIGURE 7.11 Robyn's drawing of a mathematician**

Robyn's designated identities were related to both her need to learn and know how to do the mathematics at a similar rate to her classmates and to achieve at an Excellence level or in comparison to her other subjects. Robyn's high expectations were strongly reinforced by her class placement, and her achievement and class positioning in her other subjects. It was Robyn's perception that, compared to her other subjects, in mathematics she did not achieve as well, had less understanding of the content, and found the required tasks more difficult to do. Indeed, Robyn did achieve at a higher level in her other subjects, than she did in mathematics.

As I get good academic results in other subjects but not in maths, I can't see why I don't achieve so well in maths (Robyn<sub>MetaphorsYear10</sub>).

Over the years as maths got harder and when I couldn't solve a problem I got real upset because I wasn't used to not being able to do school work (Robyn<sub>FurtherResponseYear10</sub>).

I think I'm not as relaxed ... I really enjoy Social Studies and I think I can take in a lot there ... but when I get to maths it's not a strong subject for me ... (Robyn<sub>InterviewYear10</sub>).

It can be very negative. Maths has a strong effect on me because it's the one subject that I find really hard, but I get good results in everything else. If I could really understand maths well that would mean I'd be good at everything at school (Robyn<sub>EndofYear10</sub>).

Robyn believed someone's ability in mathematics was an innate part of his or her personality.

If I don't understand something, sometimes I do or feel like giving up because it feels like 'maths is not my strength'. It takes quite a logical way of thinking, so not all personalities of people are suitable to say they find maths really easy (Robyn<sub>MetaphorsYear10</sub>).

I feel there's a lot of very intelligent people in my class that have a 'knack' for maths and it comes really easily to them – sometimes that makes me feel a bit stupid – but it helps to know I'm far stronger in other subjects to them (Robyn<sub>EndofYear10</sub>).

Robyn's parents were particularly significant narrators of the stories that contributed to her designated identities and her views on mathematics.

Robyn has an excellent mind although she would say [maths is] her weakest subject – but she gets top in at least two subjects in the achievement class (Robyn<sub>MumQuestionnaireYear10</sub>).

Robyn is very good at maths and applies herself well. Robyn thinks she is not very good at maths because she often compares herself with those who are brilliant in the subject. She takes a while for new concepts to sink in while others grasp these concepts very quickly (Robyn<sub>DadQuestionnaireYear10</sub>).

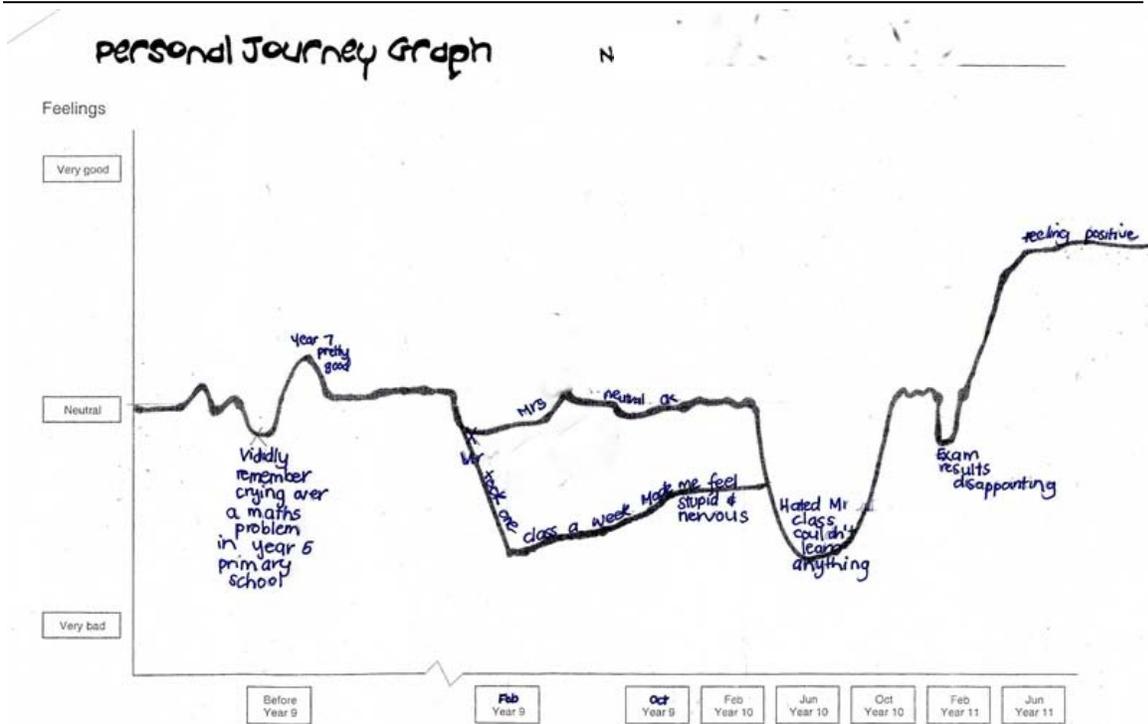
Robyn's mother, when discussing her own schooling, sounds similar to Robyn in terms of comparisons to others in the class and mathematics being innate. Robyn can be 'heard' in her mother's stories. These are significant and contributed to Robyn's sets of identities.

I enjoyed [maths] very much at primary but lost my confidence at secondary level. I was in the top class so compared myself to other, more able, students and felt dumb at times (RobynMumQuestionnaireYear10).

Art and music are my strengths, not maths (RobynMumQuestionnaireYear10).

In terms of mathematical achievement, Robyn considered herself to be positioned about the middle of the class, though acknowledged she may be slightly above average compared to the whole year group (RobynEndofYear10). Indeed, Robyn's achievement in the PAT positioned her in the 80<sup>th</sup> percentile, well above average in her class, her school, and her age group in New Zealand.

Despite this, Robyn's expectations of herself were very high, and she rarely met them, resulting in somewhat contradictory macro-feelings about mathematics. In her personal journey graph (see Figure 7.12), her macro-feelings are generally neutral, though she stated she did not "enjoy" the subject, and it made her feel bad about herself. She felt good about her other subjects and enjoyed doing them (RobynAutobiographyYear10), so in contrast to these, the neutral line is a lot more negative than it perhaps seems.



**FIGURE 7.12** Robyn's personal journey graph

Robyn attempted to close the large gap between her designated and actual identities through intense engagement in the mathematics. She worked steadily throughout the lesson, had little social talk, and completed all homework tasks. Influenced by her father, Robyn believed difficulties in mathematics could be overcome by hard work.

I was not brilliant at maths so had to work hard at understanding the subject. I always asked questions. In maths you need to work hard, put it out, don't give up, it is a logical subject (RobynDad<sub>QuestionnaireYear10</sub>).

I think Dad thinks I underestimate how good I am because I put myself down in the maths department because I don't think I'm as good as lots of other areas. I get frustrated and annoyed and Dad is like ... you are good at it. It just takes a while. I think he tries to encourage me more than I encourage myself (Robyn<sub>InterviewYear10</sub>).

I know I am not excellent at maths, but I try my hardest and work hard and get satisfactory results most of the time (Robyn<sub>EndofYear10</sub>).

To complete a mathematical task Robyn believed she needed to follow a set of defined steps or rules. She did not construct these steps herself; rather she learnt how to do them and then practised them to remember them all so she could "really understand it".

I just start off with the easy steps that I know how to do but once it gets more complicated I think a lot of the time I give up ... It almost goes over my head kind of thing and I think oh ... how the heck do I do this? I get ... maybe I get confused. I need definite steps of how to do it that I keep going over so I can really understand it (Robyn<sub>InterviewYear10</sub>).

I want to grasp everything with certainty (Robyn<sub>EndofTrigYear10</sub>).

When Robyn met her expectations, she experienced positive micro-feelings, but these were not significant enough to result in her thinking she was “good at” mathematics or contribute to her macro-feelings about the subject. This could perhaps explain why she did not seem to highlight her examinations in Year 9 when she discussed her macro-feelings about mathematics. Her strongest positive experiences were often when she ‘got’ or understood a concept straight away.

I feel positive emotions in maths when I figure out a problem (Robyn<sub>EndofYear10</sub>).

When Robyn’s experiences in the mathematics classroom resulted in her not feeling like she had met her expectations, these resulted in negative micro-feelings and contributed to actual identities about her ability.

[I feel negative emotions in maths when] I get stuff wrong and others in the class got it straight away. I hate not being able to figure out maths problems because I can do it in every other subject (Robyn<sub>EndofYear10</sub>).

When I can't understand a part of maths I feel frustrated and sometimes stupid (Robyn<sub>MetaphorsYear10</sub>).

[I feel] worried and frustrated [when I am] not getting a maths problem or new concept because I really rely on being able to get stuff. I like to feel intelligent (Robyn<sub>GroupInterviewYear11</sub>).

When Robyn experienced micro-feelings of confusion and frustration she often gave up.

When I'm negative I just give up really easily ... it's like no I can't do this. It's too hard. I don't know ... I just give up more easily.

She also habitually asked for help from her teacher and her classmates.

[I need the teacher to] to go over answers I get wrong and understanding how I can change it next time (Robyn<sub>AutobiographyYear10</sub>)

I [like to learn] ... I think with a teacher explaining to me and helping me to understand on my 'level' works best (Robyn<sub>AutobiographyYear10</sub>).

I get frustrated with [maths]. Can't you just tell me what it is? Get someone else to do it for me ... Sometimes the simple ways of working it out are all right ... but once it gets a bit more complicated I get the teacher to help (Robyn<sub>InterviewYear10</sub>).

For me, maths is like a silent black and white movie because the people don't talk, like maths ... but it can be explained to you. You either understand the storyline by following the action and another person explaining it, or you sit back, bewildered – having no idea what is going on. Even if a person told you the whole movie in detail, you either, get it and click, or you still have no idea and give up. You are excited and happy if you understand and get the satisfaction of seeing the end of the movie pan out like you thought it would (Robyn<sub>MetaphorsYear10</sub>).

Like Robyn, those students who felt the most intensely negative micro-feelings were those students who felt they had engaged highly in the mathematics but still did not achieve success. This often was connected to students' worst mathematics experiences. Ann, for example, felt upset and angry with herself when she was not able to work out a problem.

I try and figure it out ... an easy way of doing it and I look in the textbook at the instructions. I try and figure it out like that and then ask. If I still can't do it, I feel like I can't achieve [and I am] annoyed at myself (Ann<sub>GroupInterviewYear10</sub>).

The seating arrangements in the classroom affected all of the students in the class, as discussed in section 6.3. For Robyn, the seating arrangements were particularly significant because of her expectations, her competitive relationship with Angela, and her dependence on help. In the initial seating plan in Term One (see Figure 4.3), Robyn sat behind Angela and Colin. For the rest of the year with the exception of one unit where the students worked in groups, Robyn sat next to Angela and Joanna in the middle row of three desks. Angela and

Robyn were friends and therefore even when there was not a seating plan they had little choice but to sit together.

We're expected to sit together because we're such good friends, but ...

(Robyn<sub>InterviewYear10</sub>).

Robyn was very conscious that Angela was in the top group of mathematicians and achieving at the level of Robyn's own designated identities.

Well, me and Angela ... have a lot of competition even though we don't talk about it but inwardly I can feel that there is a real expectation ... I know she's better at maths than me ... but I always feel like I should be doing good ... and when she gets better than me I think she beat me and it just frustrates me how she's so good at it sometimes

(Robyn<sub>InterviewYear10</sub>).

I'm looking at changing the seating plan ... Robyn works really hard ... I don't think things come as easily to Robyn as they do to Angela and they're friends and there's lots of competition there and Robyn has to work a lot harder to achieve to the same level as Angela ... her parents last night said that it's taking a toll on her ... Robyn feels that she has to keep up. Robyn's parents have asked that they don't sit together ... and I've noticed they don't actually sit together in maths, I've put them one behind the other ... it might be interesting to put them in completely different places in the classroom ... so they aren't as aware what the other ones are doing

(MrsBrown<sub>InterviewYear10</sub>).

Robyn's feelings about Angela affected her engagement in terms of seeking help and clarification. Given that Angela often felt frustrated about helping Robyn, Robyn's feelings were not surprising.

[I prefer to work] by myself, because I'm not worrying whether anyone else gets it or not. It's easier to just get on with things by myself (Angela<sub>AutobiographyYear10</sub>).

If I'm trying to do my own work and Robyn's like 'Angela how do you do this?' and I'm like 'You'll have to ask the teacher' ... I don't have a lot of patience as a person. Sometimes it is a little frustrating when I can see the answer and no one else can

(Angela<sub>InterviewYear10</sub>).

I avoid asking Angela for help because I don't want her to know that I need it ... sitting next to a brain-box makes me feel intimidated and stupid (Robyn<sub>InterviewYear10</sub>).

Even when Angela sat near to Robyn rather than next to her, Robyn was conscious of Angela.

If I'm trying to clarify a question or something ... I know she's listening. Like her and Colin were sitting next to each other and I was quietly discussing it with Jason and I know that they can hear yeah ... and I can hear they're thinking like you're supposed to be bright and I'm like oh ho but maths is not my strength. It's quite frustrating (Robyn<sub>InterviewYear10</sub>).

Robyn thought that Joanna, who was at a similar level in mathematics, was helpful to sit next to.

If I'm sitting with people good at maths I feel stupid, but if I'm sitting with others with the same ability as me it lifts my confidence (Robyn<sub>EndofYear10</sub>).

Yeah, Joanna and I work well together. I was talking to Mrs Brown about it a while ago and she said we are on the same kind of learning river thing and when we work together we actually understand it better and we can go through it slowly and understand it (Robyn<sub>InterviewYear10</sub>).

Robyn began Year 10 with low confidence in mathematics, but during term one, it began to improve.

It's been good with Mrs Brown because she's been able to ... I can understand her and ... she goes through it step by step with me and she will come and explain more if I need it (Robyn<sub>InterviewYear10</sub>).

In Robyn's personal journey graph in Figure 7.12 above, Year 10 was dominated by a large downward curve, which Robyn attributes to the relieving teacher, Mr Murray. Like others in her class, Robyn felt Mr Murray did not have good class control

I found it so hard to concentrate in class and just to take it all in and ... because it takes a while as I said ... wow ... everything was so noisy (Robyn<sub>InterviewYear10</sub>).

She also thought that he was not as good as her regular teacher at explaining new concepts and not as approachable (Robyn<sub>InterviewYear10</sub>) which would have been difficult for Robyn because asking questions was part of her habitual pathway of engagement.

For Robyn, new seating arrangements near the end of Year 10 when the students briefly worked in groups were a relief because she no longer sat near members of the top group. Interestingly, her language changed from help-seeking to working with students.

I worked with people that weren't super intelligent and could grasp it instantly. That was good for me because sometimes I feel inferior or not smart enough (Robyn<sub>EndofTrigYear10</sub>).

I really enjoyed having a change in classroom environment and teaching style. In general I felt it was a stress-free subject that I was able to understand easily (Robyn<sub>EndofTrigYear10</sub>).

Robyn's personal journey graph showed a slight downward dip due to "disappointing" examination results (Robyn<sub>PersonalJourneyYear11</sub>). Robyn studied for the end of year mathematics exam for two and a half hours, a comparatively long time compared to her classmates. To study, she wrote out notes, did exercises in her homework book, and did practice sheets (Robyn<sub>EndofYear10</sub>). In Year 10, in contrast to her Year 9 mathematics examination, Robyn received no Excellences and did not achieve in the Number strands. In all of her other subjects she achieved at an Excellence level (Robyn<sub>ReportYear10</sub>). Although Robyn was pleased with her results in other subjects, in mathematics, she felt she did poorly.

Worse [than I was expecting]! Yes, I forgot a lot of stuff and I was in a huge rush because the papers were so long! (Robyn<sub>EndofYear10</sub>).

### 7.3.3 Year 11

Robyn attributed much of her anxiety about mathematics to the comparisons she made to Angela, which were exacerbated when they sat near to each other and because they were social friends. In Year 11, Robyn was placed in MAT101 with none of the students from the top group. There were no longer constant comparisons with Angela within mathematics class. In Year 11, without Angela's presence in class Robyn felt positive about mathematics. This change in her feelings is shown by the steep upward trend in her personal journey graph (see Figure 7.12). Robyn's engagement in the mathematics had also changed. Robyn sat in a group

with Frank and Amanda and talked about being more relaxed, though she continued to engage to a high level in the mathematics. She perceived the others in her group were of a similar level to her. Rather than constantly seeking help, Robyn discussed the problems with her group, particularly Frank.

It's good to be in a different class from the achievement class because MAT101 just feels a bit smarter ... in the way that we don't have other really academic mathematicians to compete against. It's much easier on me. There was like the non-vocalised competition all the time but this year it doesn't really bother me that much. I see them around but I've moved on (Robyn<sub>GroupInterviewYear11</sub>).

[This year I am out] of the achievement class where there were extremely intelligent people. My new MAT101 class has improved my self-esteem because I don't feel a bit dumb because I get maths problems faster than other classmates now and I can help them (Robyn<sub>AutobiographyYear11</sub>).

Robyn is not as 'intense' as I remember in Year 9. She seems more confident in her skills and puts these forward readily. Her working is outstanding and she is working to see if Merit is a realistic option for standards. Excellent work output and work ethic (MissHill<sub>FeedbackYear11</sub>).

Robyn attributed some of the change to the nature of NCEA where credits are awarded regardless of the passing grade received. These credits were tangible evidence of her ability in mathematics. Also, the broad band of achieving grades did not differentiate between students. Credits were credits.

Last year it was always ... Oh, you've got to get Excellence. It was like striving because we are the achievement class rah rah rah. And now, if you get Achieved you get your credits anyway ... (Robyn<sub>GroupInterviewYear11</sub>).

In her NCEA external examinations, Robyn received Achieved grades in mathematics. In her other subjects she got mostly Excellence grades and a small number of Merits. Mathematics was the only subject she did not get an Honours award in at prize giving. Robyn chose to continue to participate in mathematics the following year when the subject was no longer compulsory.

Getting acknowledgement of progress with credits during the year helped Robyn to experience more positive affect. She achieved at the same level, yet felt better because her designated identities had changed. She now expected to achieve credits, rather than achieving similar results to classmates or her other subjects. Her designated identities, rather than her actual identities had changed.

### **7.3.4 Robyn's relationship with mathematics**

Robyn's relationship with mathematics in Year 10 can be characterised by hard work, anxiety, and frustration. Robyn had a different relationship with mathematics than she did with her other subjects, which is not an unusual finding in this or other research (e.g., Boaler et al., 2000b). Robyn's anxiety and frustration stemmed from this difference. In her other subjects, Robyn considered herself and was considered to be in the top group of achievers. This performance and her placement in the achievement class meant that she had similarly high expectations in mathematics. Her designated identities were all about her need to achieve similarly to her other subjects and similarly to students in the top group in mathematics.

In contrast to these designated identities, Robyn did not perform in mathematics as well as in her other subjects. She found mathematics difficult, and "menacing", and so she did not consider herself to be a member of the top group of achievers. Robyn was unable to meet the expectations of her designated identities, and mathematics was a source of great anxiety for her.

Although carefully crafted stories about one's destiny may sometimes work wonders, they are also likely to backfire when the burden of too ambitious, too tightly designated, or just ill-adjusted identities becomes unbearable (Sfard & Prusak, 2005a, p. 51).

There is some contradiction between Robyn's designated identities and her view of her own mathematical ability. Robyn had expected to perform at a high level, yet had very low confidence in her ability. Robyn accounted for the difficulty she experienced by saying that she was not naturally good at the subject. Mathematics was "not [her] strength". Other people had the "knack", and she did not. Other students in the class with low confidence had an entity view of their intelligence (section 6.2.1). They thought their intelligence was fixed, and did not seek to close gaps in their identities through engagement. They did not persevere when they experienced difficulty. It is somewhat unclear what view of intelligence Robyn

had. Robyn knew she was not “stupid” because of her strength in her other subjects. Despite feelings of frustration and failure to meet her expectations, encouraged by her parents, Robyn also had a high level of engagement in the mathematics. This makes Robyn unlike the other students with an entity view of their intelligence, who thought there was no point in trying. Robyn believed her mathematical ability could be compensated for with hard work, rather than improved.

Robyn was very affected by her relationship with mathematics because of her view of mathematics and the way she engaged in mathematical tasks. Boaler, William and Brown's (2000a) research on high ability groups found that girls in particular were affected by fast-paced lessons because they wanted an in-depth understanding of what they were doing. Robyn certainly wanted “to grasp everything with certainty”. Robyn sought instrumental understanding, as defined by Skemp (1976). ‘Understanding’ to Robyn meant knowing the “definite steps of how to do it” and knowing “the storyline” of mathematics. She did not seek to go “beyond the operative ability of solving problems” (Sfard, 2008, p. 29). Robyn's view of mathematics was that it was a set of procedures, and her focus was on learning these “off by heart”. Reinforced by the routines of the classroom (section 5.2.1), Robyn seemed to assume that if she learnt the procedures she would understand the mathematics as well as she understood her other subjects. The amount of content and the fast-paced lessons in the achievement class meant that learning the procedures fully was difficult for her to accomplish.

Robyn may have engaged highly in the mathematical task in terms spending time and effort, but she did not have effective engagement skills. Although Robyn certainly had good concentration, she was similar to students in only expecting to engage superficially with a problem because she asked for help as soon she became confused (section 5.1). She talked about wanting to give up when she became confused, but instead of giving up, she asked for help. Help-seeking was described by Yair (2000) as an indicator of engagement (section 6.1.1). For many of the other students who asked for help as soon as they became confused, seeking help was a form of disengagement. In Robyn's case, she had low expectations that her own effort would lead to success in the task, and was reliant on the teacher and others to help her with the steps of how to do it.

The teacher routinely gave students assistance during textbook work (section 5.2.1). According to Boaler (2002b), teachers give lots of help because they have limited time to allow students to explore themselves, This is similar to the teacher described in Lange and

Meaney's (2010) research who seemed to view learning as the successful completion of the task and was seen to do the work of the children. Teachers were also described by Boaler (2002b) as wanting to prevent the students from experiencing failure. Teachers thought helping students would build mathematical confidence and, ultimately, help the students' learn mathematics. Like the students in Boaler's (2002b) research, Robyn was dependent on this help. Unlike Colin and Philip she did not learn to think for herself. She remained reliant on learning the rules for getting the correct answer, rather than learning how to construct the procedures she needed for herself. She did have some mathematical integrity, wanting to go over and over an answer until she knew the steps to get it. Unlike Colin she did not seem to have an emotional engagement with the mathematics – mathematical intimacy. In Year 11, Robyn's designated identities reduced to enable her to close the gap between her actual and designated identities. As Robyn continued with mathematics, her view of mathematics, and her engagement skills made her vulnerable to further anxiety and non-participation as the number of procedures in mathematics that she needed to learn continued to accumulate.

## 7.4 Ruth



*Ruth has a medium build and long, blonde, well-maintained hair. She often wears obvious make-up and a non-regulation jacket with a fluffy hood. At her enrolment, the year before the research period, she was described as a pleasant student, who was looking forward to beginning at the school.*

**FIGURE 7.13 Ruth**

### 7.4.1 Prior to the research period

Ruth enrolled in the research school at the beginning of Year 9, two years later than many of her classmates. Her small, rural, contributing school described her as having above average motivation and generally “sound” in-class behaviour. She had a “select group of friends” and “liked to be the group leader”. Her relationship with teachers was described as “fine, once rapport is established” (ContributingSchool<sub>EnrolmentYear9</sub>).

Prior to Year 9, Ruth described mathematics as her best subject (Ruth<sub>EnrolmentYear9</sub>) and she had positive macro-feelings about it – she felt very positive about the subject overall (Ruth<sub>PersonalJourneyYear11</sub>). Indeed, she was described as a very able mathematician who enjoyed problem solving and thinking outside the square (ContributingSchool<sub>EnrolmentYear9</sub>). Furthermore, by being chosen to represent the class in an external mathematics activity, Ruth was recognised as a top mathematician.

I did a university maths thing that went around the primary school. You got out of maths and you had to sit in another room and do all these random problem solving questions and stuff. Yeah ... you had to be like a high achiever in the class and stuff and in Year 8, I got the highest in our school and I was like yeah! (Ruth gives a whoop of joy). I had to get all these certificates in front of everybody. Yep. I got best in the school (Ruth<sub>GroupInterviewYear10</sub>).

At her enrolment in the research school in Year 9, Ruth was placed in the achievement class. During that year her reports were consistent across her subjects. She was described variously as ‘polite’, ‘enthusiastic’ and with ‘good skills’ but they also alluded to an inconsistency of focus and completion of work with statements such as “if Ruth puts her mind to it” and “Ruth will need to keep focussed next year” (Ruth<sub>ReportsYear9</sub>).

In mathematics, Ruth felt that the change of schools and her experiences in Year 9 had a profound effect on how she felt about mathematics.

At my old school, maths was pretty easy and it was quite a small class ... you got help like all the time and then at the start of last year ... I sort of went through ... I went to ... the big school and stuff ... I went to a bigger class and kind of lost interest in maths because you just didn't seem to get the help. [I needed the help] to keep me going and I didn't get it and I've just like lost interest in it. Yeah ... I hate maths now. I just

didn't like Miss Hill. We just didn't get along. She sort of. ... like she couldn't really explain things and when you asked her for help she was like I'll be there in a minute and she wouldn't come back and if she did she wouldn't explain it at all like she'd just say what she did the first time and she got annoyed because she said 'you weren't listening' (Ruth<sub>GroupInterviewYear10</sub>).

Ruth's mathematics teacher from Year 9 questioned the class placement of Ruth.

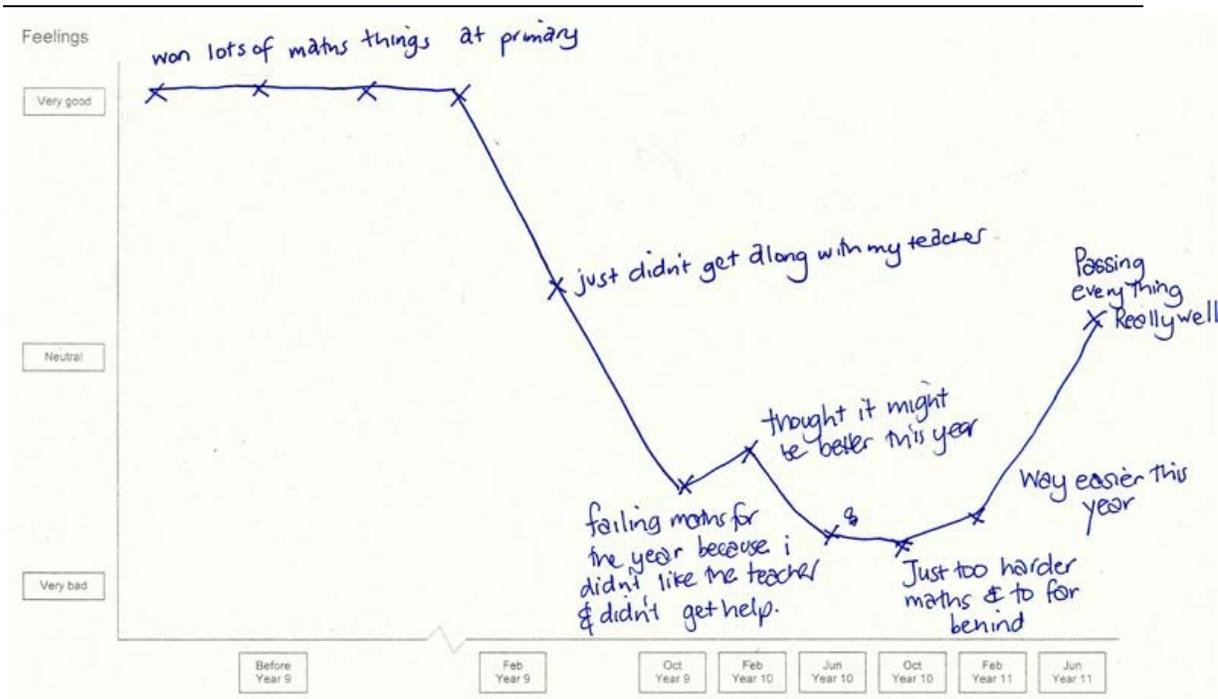
I don't know why Ruth is in that class ... I really couldn't do anything with [her]. Her parents are very keen for her to do well, but Ruth's just a bit ... she's in the jacket brigade and she pushes ... she pushes makeup she pushes boundaries she pushes uniform. ... I think probably her and Tia will be the only two next year that don't go into a MAT101 class ... Maths is not her thing ... she's not there ... Ruth can do what Ruth wants to do in class (MissHill<sub>InterviewYear10</sub>).

She described Ruth as the leader of the "jacket brigade". This group of girls often flouted uniform rules and could be identified by wearing jackets with a fluffy hood, makeup and several earrings. They often did little mathematics, preferring to talk socially, eat, and use their mobile phones for sending sms messages. Miss Hill described how other students' behaviour was affected by their potential affiliation with this social group and, in particular, Ruth.

Bridget walks in the shadow of Ruth ... she just sort of sits out there on the peripheral. Every now and then she does the jacket thing and the makeup thing. I don't know whether it is to keep her profile up in the group or what. I had to keep ... she was probably one of the girls that I monitored really closely last year for bookwork. She'd not bring her book ... but the Angelas and the Robyns ... they don't need to get involved in that (MissHill<sub>InterviewYear10</sub>).

Interestingly, Ruth's mathematics report from Year 9 was somewhat inconsistent with her teacher's memory of her.

Ruth has worked steadily this year. She is working to the level required. Year 10 will need to see her follow up on homework and assignment tasks right from the start of the year (MissHill<sub>ReportYear9</sub>).



**FIGURE 7.14** Ruth's personal journey graph

Ruth's designated mathematical identities were initially related to her expectations that she would be successful, mathematics would be easy, and that she would get the help she needed. These designated identities were not met in Year 9. Ruth came from a small rural school, the class was much bigger than she was used to and she was streamed into the achievement class. In Year 9, Ruth's performance and her doing of the mathematics positioned her low in the class. There was a gap between her designated and actual identities therefore she did not get the good feelings she associated with success in mathematics. Ruth's engagement to close the gap was affected by two factors: her strong social needs to belong and her relationship with the teacher. Ruth talked socially because of her strong social needs and therefore often did not complete the work required of her. Her social needs led her to challenging school rules in order to gain a leadership position among her classmates. Miss Hill required Ruth to conform to the requirements of the school in terms of uniform and make-up, and the requirements of the class in terms of behaviour. This, compounded by needing to give help to many students in a big class and her expectations of Ruth, possibly affected their relationship and helping behaviours. An important component of Ruth's habitual pathway of engagement was her seeking help, and without this she felt unable to close the gap. Yet, Ruth was still achieving within the expectations of her year level. Indeed, her PAT tests in Year 9 and 10 showed she was in the top half of students of her age in the country. Yet her disengagement ensured that her position near the bottom of the class became cemented as she missed opportunities to

learn the mathematics. At the end of Year 9, Ruth strongly disliked the subject of mathematics, as seen on her personal journey graph in Figure 7.14.

### 7.4.2 Year 10

**TABLE 7.6 Ruth's relationship with mathematics at the beginning of Year 10**

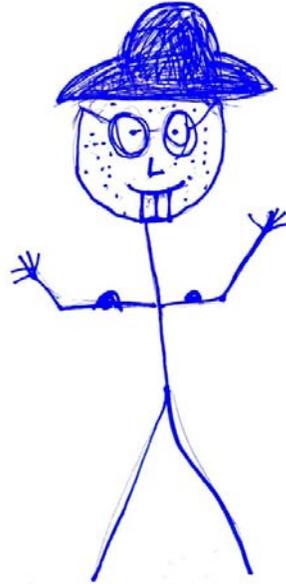
<b>View of mathematics</b>	A group of topics. Considered important by some. Not part of my future.	
<b>Mathematical knowledge</b>	There are techniques to help you do things easily. I wouldn't even know my times tables. Learning stuff means knowing what to do.	
<b>Macro-feelings</b>	I hate maths. Maths is plain old strange.	
<b>Identities</b>	Actual	Designated
	I feel stupid I should not be in the achievement class. I am the dumbest in the class.	I should try and catch up to the rest of the class. I expect help when I need it.
<b>Habits of engagement</b>	I just want to talk and not think about maths. I want to get the right answers quickly, without thinking. I want to get someone else to do it for me. I need help to keep me going.	

At the beginning of Year 10, Ruth's relationship with mathematics (summarised in Table 7.6) was very different from the other students discussed in this chapter. When asked to define mathematics, Ruth did not provide an overall concept of what mathematics was, instead simply providing a list of topics in mathematics

Numbers, symbols, algebra, prime numbers, graphs of many types, calculator, books, area, probability, geometry (Ruth<sub>MetaphorsYear10</sub>).

She was ambivalent about whether mathematics was an important subject of study. Posed with the question of whether she would enrol in the subject if it were no longer compulsory, Ruth wrote, she “would probably take it but, not because I like it but because I need it” (Ruth<sub>AutobiographyYear10</sub>). On the same day, however, she was neutral about whether or not mathematics was a useful or practical subject (Ruth<sub>AutobiographyYear10</sub>). Ruth's mathematician, seen in Figure 7.15 below, was of a spotty, buck-toothed, glasses-wearing stick figure. Even though Ruth did not add any comments to the diagram, it is clear that being a mathematician was not an attractive prospect for Ruth. Ruth did not see mathematics past her immediate future (Ruth<sub>GroupInterviewYear10</sub>). Mostly, Ruth wanted to leave school as quickly as possible to

work with racehorses (Ruth<sub>GroupInterviewYear10Year11</sub>), and only when Ruth talked about horses did she become animated.



**FIGURE 7.15 Ruth's drawing of a mathematician**

In Year 10, Ruth's mathematics teacher, Mrs Brown, was also the dean of that year level. She had a meeting early in Year 10 with Ruth and her mother to discuss the possibility of Ruth being moved out of the achievement class.

Her marks at the end of last year were not good in all subjects so we had a meeting with Mum earlier in the year and if her marks don't improve then she would be moved out. Her Mum and Ruth don't want to be moved out (MrsBrown<sub>InterviewYear10</sub>).

Associated with this, Ruth's designated identities at the start of Year 10 were associated with catching up with the others and to meet the class placement designated identities of the achievement class described in section 6.2.2. She wanted to close the gap between her actual and designated identities.

This year is hard because I have to catch up (Ruth<sub>MetaphorsYear10</sub>).

Being in the achievement class had an effect on how I feel about maths because it made me learn more because everyone was smarter than me so I wanted to catch up (Ruth<sub>AutobiographyYear10</sub>).

Ruth viewed Mrs Brown as particularly strict on make-up, but thought she was better at giving help and making her work than her previous teacher.

If I need help she explains it better, more simple so I don't feel silly ... and she doesn't get angry if I don't understand. [She needs to] not be so strict on make-up, it doesn't make you dumber (Ruth<sub>AutobiographyYear10</sub>).

With Mrs Brown you actually have to do the work (Ruth<sub>GroupInterviewYear10</sub>).

However, Ruth continued to have a very low opinion of mathematics. Mathematics was, for Ruth, “boring, tiring, plain old strange, [and] a pain in the bum” (Ruth<sub>GroupInterviewYear10</sub>).

Maths is like poos,  
Brussel sprouts,  
A cold wet windy day,  
I would leave it on my plate,  
A crusty old bus, a turkey,  
A broken window, or classical music (Ruth<sub>MetaphorsYear10</sub>).

I just feel like ... ohhh maths again. A whole hour. I just can't be bothered being there (Ruth<sub>GroupInterviewYear10</sub>).

Ruth did not feel successful or confident in mathematics and she often felt out of control and nervous. She was also well aware of her class positioning and her teacher's opinion of her mathematical ability.

I suck at maths now. I wouldn't even know my times tables (Ruth<sub>GroupInterviewYear10</sub>).

I'm like augh, because we've hardly even learnt the last [topic] and we're pushing on to another one (Ruth<sub>GroupInterviewYear10</sub>).

When I can't do something I feel really like stupid because like we've got a real smart class and everyone can do it and you're like ... yeah you feel kind like stupid ... like you shouldn't be there (Ruth<sub>GroupInterviewYear10</sub>).

Mrs Brown ... knows I have trouble with [maths]. She always comes over and checks on me. [She thinks I'm] like the dumbest one in the class (Ruth<sub>GroupInterviewYear10</sub>).

[Teachers] seem to get shitty oops angry at me if I don't understand it. They just think that I'm not listening. I'll listen at the start but if they don't take any interest ... well I'll just like ... (Ruth's voice trails off) (Ruth<sub>GroupInterviewYear10</sub>).

For Ruth, in mathematics it was important to get the answer rather than to understand the mathematical concepts. When she came across a problem that she perceived to be difficult she engaged only very superficially, if at all.

I'll sort of like stare at it for a while and see without even trying ... see if there is a technique you can get to ... like do it easy ... if I can't do that I'll ask the teacher for help, and if I can't do it again, I'll get the answer off somebody and like ... yeah ... I'll just write it down (Ruth<sub>GroupInterviewYear10</sub>).

If I do textbook work, I do cheat. I do some of them, but by the time I do 10 questions, this is boring so I just look in the back [of the textbook and get the answer] (Ruth<sub>GroupInterviewYear10</sub>).

I feel happy when I do something right ... if I get a good mark or something. The other day we were given questions and we were getting them right and we were like. Yeah! We're onto it. But then like if I try and get it wrong I'm just like I'm going to embarrass myself (Ruth<sub>GroupInterviewYear10</sub>).

Indeed, despite the meeting with Ruth and her mother early in Year 10, Ruth's engagement in mathematics was very low.

[I feel] like I can't be stuffed. I feel like just sitting down and talking (Ruth gives a pause of three seconds) it's like, it's maths and you just GRRRRR! Sometimes it's like you can't be stuffed and then you get into class and you're wasting time because you are like I just don't want to be there. I'm just sitting there mucking around ... wishing the class would end (Ruth<sub>GroupInterviewYear10</sub>).

Ruth! (Mrs Brown sounds exasperated). Ruth is struggling in maths. She struggles to do the work, she struggles to concentrate, and she's always getting distracted by others. I don't think she wants to do the work. She is going to have to work really hard to get a minimum result so what's the point? It's not important to Ruth to achieve ... it just doesn't interest her ... she might just be doing the bare minimum to get by and then spends the rest of her time socialising. Ruth doesn't care. ... Her mum says that

she does work at home but I'm not seeing anything in class that shows she is doing work to understand. The only time I ever see her is when she is not doing what she should be doing and I say 'come on Ruth you've got to do your work' so it's becoming negative for me because she won't participate ... she's not giving anything positive to the class ... it's always distracting the people in front of her or not doing her work or not getting her books out or ... (MrsBrown<sub>InterviewYear10</sub>).

When Ruth was asked if she thought who she sat near affected her level of engagement, she laughed uproariously.

Totally ... I don't do anything ... I find it hard to focus. I get distracted really easily ... [When] Mrs Brown moved me beside Peter [who is not a friend], Moira [my best friend] was just in front of me. Ha! (Ruth<sub>GroupInterviewYear10</sub>).

If I sit beside a brainy person I just do worse because I just copy them ... the teacher just looks at your book and you got everything right so you're sweet ... no hassle. It's easier [to copy them]. Mrs Brown thought it was a good idea to put me beside Peter. He's really smart but I was like 'Peter, what's the answer?' and he'd just pass me his book. Mrs Brown would look at it and she'd be like 'oh yeah yeah she's doing all right'. Get to the end of the year exams ... fail (Ruth<sub>GroupInterviewYear10</sub>).

In Term 2, Mr Murray taught the class, and there was no seating plan in place. Ruth sat amongst other jacket brigade members. Ruth's already fairly low level of engagement in the mathematics dropped further. She was often the last in class to get her books out to begin working and spent much of her time in off-task social talk. On one occasion she did not get her books or pens out for the whole period. She often had her head turned away from the teacher when he was explaining a concept and didn't look at her book (or him) when he was talking.

Ruth had not brought her exercise book and was working on refill pad. She did not complete the starter, nor did she mark the work she had done when Mr Murray called out the answers. Ruth then did not do any work or even pick up her pen for the rest of the lesson, about forty minutes. During the class she managed to eat a large filled-roll (which took several minutes) and sent sms messages on her phone several times. Despite this overt non-engagement, during this time the teacher did not approach Ruth or reprimand her (Researcher<sub>ObservationYear10</sub>).

When this observation was read to Ruth during her interview, Ruth responded.

With Mr Murray he doesn't tell me off for makeup and we just sit there (Ruth starts laughing). To be honest, I've only done half a page of work this whole term (Ruth's laughter continues). That's why I didn't want to hand my book in to you. And you can just sort of talk real loud ... we can just sit there yelling. [Maths is] way different. In my other classes ... I'll do work. I'll talk to people but I'll do work at the same time but here I just talk. I don't do anything ... Mr Murray thinks it's easier to let [us] do what [we] want (Ruth<sub>GroupInterviewYear10</sub>).

Ruth's described how her continuing lack of engagement in mathematics was associated with her understanding, feelings and achievement in mathematics.

Yeah ... we got real dumb. You're coming in though halfway through ... you start listening when he is halfway through. And I just don't feel like trying because I know I'm going to get it wrong. Eeeegh ... you just think not again like you just don't pay any attention to it at all ... get someone else to do it. And you just sort of tune out. I don't know. I'm quite happy just chilling talking about my weekend (Ruth<sub>GroupInterviewYear10</sub>).

Not understanding it ... makes you feel pretty stupid. And then the teacher acts like you are wasting their time. [The feelings get big] when they all start building up and you realise that you're not getting it and you've pretty much failed the year and you can't catch up. There's so much in maths (Ruth<sub>GroupInterviewYear11</sub>).

Ruth's feelings about the subject of mathematics, her habitual pathways of engagement, her relationship to the teacher, and her strong social needs meant that she was unable to meet her designated identities from the start of the year relating to catching up with the rest of the class. When she had any difficulties in mathematics she did not try to close the gap with engagement. Rather, she copied the answers from her classmates or disengaged through socialising. She felt helpless and did not feel supported by her teacher. There was "so much" to mathematics, so without the necessary engagement, it was impossible for Ruth to close the gap between her actual identities and her designated ones associated with being in the achievement class. These designated identities changed to help her cope with her negative feelings about failure and became about appearing like she was keeping up while doing the bare minimum of work. These designated identities adjusted to her being a social person who sat for a few hours in maths each week. She got further behind her classmates.

Eventually, at the end of term two, Ruth was moved out of the achievement class.

Ruth would be one of the less able in the class and I think she feels that she is [at] the bottom of the group so there is really no point in working hard or giving it a go ... it doesn't matter. I think if she was in a class that wasn't the achievement class then she would feel better about it ... put more effort in because then she wouldn't be at the bottom of the class ... she does very little work. Ruth hasn't shown any ... getting better. [She's not] trying any harder to stay so ... (MrsBrown<sub>InterviewYear10</sub>).

Ruth consistently did not meet the expectations associated with her class placement and therefore she was removed. This reinforced the class placement for the rest of the class.

The reason Ruth got moved out is because she wasn't doing any work or anything, which I suppose is fair (Sean<sub>InterviewYear10</sub>).

I think like last term I wasn't really doing much and I thought I was going to get kicked out like Ruth. She was a bit annoying. She talked a lot. Just because half way through last term they said they were thinking of kicking a few people out so I felt worried (Mark<sub>InterviewYear10</sub>).

Certain people not being in my class anymore ... along the lines of Ruth sort of thing ... you concentrate a bit more (Lola<sub>GroupInterviewYear11</sub>).

Ruth was disruptive. It was good and bad in a way. It was good because it was quiet again but sad because ... she's unhappy she's going (Cheryl<sub>InterviewYear10</sub>).

For Ruth, the rest of the year was very difficult and she did not achieve the necessary examination results to be given entry into MAT101. Ruth felt very bad about mathematics and her ability in the subject. Mathematics was "just too hard" and she was "just too far behind" (Ruth<sub>PersonalJourneyYear11</sub>).

It was no good. [In my new Year 10 class] I ended up doing all the work I'd already done [and missing out other topics]. So I completely failed my exams. I didn't know what I was doing apart from the start and then ... it was just too exciting going into the other class and having all my other good mates there. I had Mr Cage. He was a real good teacher but he wasn't like the right teacher for me. He was just like too nice. I'd

just sit there in the class and he would just walk around and wouldn't say anything. He'd say, 'aren't you meant to be doing your work' and I was like ... I'll do it later. I never did it (Ruth<sub>GroupInterviewYear11</sub>).

Ruth's best results indicate that she is a capable student. However she has not really given herself a fair chance this year as she hasn't tried particularly hard in class (MrCage<sub>ReportYear10</sub>).

### 7.4.3 Year 11

Ruth began Year 11 in MAT102 with Mr Carter after trying unsuccessfully to get moved into MAT101.

MAT102 is too easy. Well my mum talked to the school and they said [I can't change]. Mr Carter said that I'd pass MAT101 in his class but he didn't think I would with Mr Powell but that would be the only class I could go into. I don't know. Mr Carter gives me lots of help. He said I need extra help to understand things but Mr Powell doesn't [give it]. Mr Carter's going to give me extra work ... so I can [do maths next year] (Ruth<sub>GroupInterviewYear11</sub>).

[Ruth is an] adequate mathematician who should be in MAT101 but was put in MAT102 because she lacked confidence, a decision I disagree with and tried to change in Term 1. I believe I could have got good results from her if she was in my MAT101 class (MrCarter<sub>FeedbackYear11</sub>).

Compared to her other mathematics teachers, Ruth felt that she had a particularly good relationship with Mr Carter.

He's cool. Just free and easy. He's pretty straight to the point. He makes me work but he never hassles me about anything else, which is what he's there for. Just what ... the teacher's there to teach really. I like it this year. Mr Carter's good (Ruth<sub>GroupInterviewYear11</sub>).

Ruth's engagement in the mathematics improved, perhaps as a consequence of an improved relationship with the teacher, a maturation and clear goals for the following year. Her designated identities again adjusted to include achievement-based goals.

I mean to pass this year ... get eight credits, so I can leave (Ruth<sub>GroupInterviewYear11</sub>).

Students need to get a minimum of eight numeracy credits to gain an NCEA Level One qualification, and Ruth's goal reflected this specification. Early in Year 11, Ruth received a report that showed a big improvement in her engagement. By the middle of her Year 11 she felt much better because she was "passing everything really well" (Ruth<sub>AutobiographyYear11</sub>). Ruth felt she was achieving the marks she was capable of "because I have no motivation to do well I guess. Maths this year is really easy for me I guess not as hard as last year, but that's probably because I'm in MAT102" (Ruth<sub>AutobiographyYear11</sub>).

If I'm tired or had a bad day I just can't be bothered with any school work but if I've got quite a bit of energy and stuff. If I'm having a good day, I'll try  
(Ruth<sub>GroupInterviewYear11</sub>).

Well behaved and gets on with what she has to. I'm aware she pushed boundaries last year and perhaps the consequences of THIS knocked her confidence. I suspect she has matured a great deal in the last 6 months (MrCarter<sub>FeedbackYear11</sub>).

Ruth, endorsing that she felt better about mathematics, also felt this affected her ability to do it.

If I don't feel good ... let's use horses. If you don't feel confident about doing a jump. If you're negative about doing it, you're most likely not going to get over it. In maths if I don't like say fractions I don't feel real good about them. Mr Carter took me aside and explained them to me and now I feel real good about them and passed them real easy (Ruth<sub>GroupInterviewYear10</sub>).

It's all pretty simple once you know it and common sense. The rules and stuff  
(Ruth<sub>GroupInterviewYear11</sub>).

Like other students from the research class when they were placed away from the high achieving students in Year 11, Ruth found that her class positioning dramatically improved in MAT102 and she was often asked for help from her classmates.

The only thing that annoys me is like is I find other people in the class always ask me what to do because I like ... get it. I understand. 'I don't get it Ruth, can you help me?' (Ruth puts on a voice). I say I don't get it either because then I'd just be helping them

the whole time. Yeah. I don't get paid to help them. The teacher does (Ruth sniggers).  
I just can't be bothered all the time (Ruth<sub>GroupInterviewYear11</sub>).

Ruth's engagement in mathematics was tenuous. In Term Two, Ruth's engagement in the mathematics dropped, perhaps because once again, a relieving teacher took the class for one term.

[Ruth is in the] top 20% in class, but effort and attendance spasmodic. 'Tolerates' maths, without complaint but does little/nothing to challenge herself or improve her maths ability (MrsWhite<sub>FeedbackYear11</sub>).

During this term, Ruth's parents separated and this may have affected her engagement.

Fairly messy at the moment with parents separation. One of the 'cool' kids. Attitude varies from moody/sulky to defiance to compliance (teenager!). Ability still hard to gauge. Inconsistent work output (English<sub>FeedbackYear11</sub>).

In mathematics, when Mr Carter came back in the third term, Ruth's engagement in mathematics again improved, she was achieving well and was attending class.

Ruth is working comfortably at this level with pleasing results (MrCarter<sub>ReportJuneYear11</sub>).

Ruth was more engaged in mathematics than in her other subjects. In science, for example, she was absent for 17 periods in term two compared to eight periods of mathematics. Her engagement in mathematics, however, diminished and remained low for several weeks. Perhaps Ruth did not engage further once she achieved her goal of getting eight credits. At the end of the year, Ruth received the eight credits she sought out of the 24 available in mathematics, but not enough credits across all her subjects to contribute to an NCEA qualification. She did not return to school the following year.

Ruth is quite an able mathematician but has lost her enthusiasm for class over the last few weeks. This course has probably been too easy and therefore boring for her (MrCarter<sub>ReportSeptemberYear11</sub>).

Ruth ended up off the rails. She'll have her eight credits but not much more (MrCarter<sub>FeedbackDecemberYear11</sub>).

In Year 11, again, Ruth's relationship with the teacher was important. Mr Carter reinforced her reliance and dependence on him and she was encouraged by his higher expectations of her. This dependent relationship did improve her behaviour. It did not help Ruth to improve her independent engagement skills. When the relieving teacher came, similar to the year before, her engagement dropped.

Mr Carter attributed her lack of engagement to boredom because of the easiness of the course. He felt she was not being challenged enough. This is perhaps an over-optimistic view of the situation. When she was challenged in Year 10, she did not engage. Perhaps both too much and too little challenge caused problems for Ruth. Certainly she did not display the necessary engagement skills to fulfil her designated identities when they were higher. When they were lower, she discovered she could achieve the bare minimum – meet her lowered expectations without any engagement and so she did. Perhaps only Mr Carter was disappointed with Ruth's results. Ruth achieved what she expected to – the eight credits. Perhaps her designated identities were finally met. It is not clear what Ruth's feelings are about mathematics beyond the middle of the year. It is not clear why Ruth disengaged. What is clear is that her relationship with school mathematics was over.

#### **7.4.4 Ruth's relationship with mathematics**

When Ruth moved into a large urban school at the beginning of Year 9, her involvement and leadership in the jacket brigade may have been part of seeking social acceptance into a class where the others already knew each other. By belonging to the group, Ruth adopted and contributed to its habitual behaviour patterns. Her engagement in the mathematics was very superficial and she often disengaged altogether. Although membership in this group would have, no doubt, been of some comfort to Ruth socially, the behaviour of this group was inconsistent with the expectations of behaviour of the achievement class and Ruth's initial expectations of success. Ruth may have experienced tension as she negotiated these different aspects of her identities (Hodgen & Askew, 2007). Ruth initially had success-oriented identities which were adjusted to incorporate her strong social needs. Although her behaviour may seem counter-productive in terms of mathematics learning, they perhaps were functional in terms of social goals.

In Year 10, although she began with achievement related designated identities, Ruth's social needs were very strong and she perceived it was too difficult to catch up to the rest of the class. Her engagement in mathematics quickly became very limited. When Ruth attempted

engagement in mathematics, she had often missed the instructions and explanations, and may not have had the mathematical knowledge required to do the task. She struggled with the mathematics, and, when she could not do it immediately and the teacher was not available to help, she disengaged. Her struggles to do the mathematics when she did engage was evidence, to Ruth, of her ability in mathematics, and because she was compelled to sit through lesson after lesson with no expectations of success, no understanding of the importance of mathematics, she continued to experience intensely negative feelings about the subject. In Year 11, despite initial renewed expectations of success and better engagement in the mathematics, her engagement again dwindled. In Year 11, she seemed to have some tenuous dependence on her teacher. This may have motivated her and would have fulfilled some of her social needs, and perhaps contributed to her engagement, but there is little evidence of this.

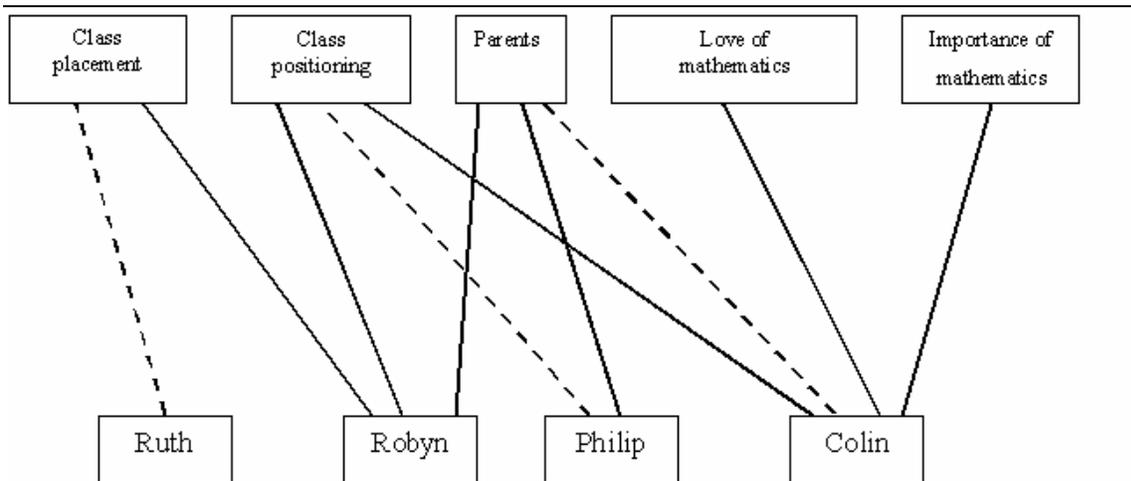
Ruth's personal journey, shown in Figure 7.14, highlights the importance of a teacher in a student's mathematical journey. Ruth had six different mathematics teachers over three years and each change in teacher had a profound effect on her mathematical journey. The teacher Ruth had was closely associated with her macro-feelings about mathematics and she was reliant on the teacher to monitor her behaviour. Furthermore, when she did engage in the mathematics, the teacher affected her micro-feelings. Ruth was very aware of her class position and her teachers' expectations of her. For Ruth there was a breakdown in the didactic contract between herself and her teachers. She was initially dependent on their exclusive attention and was reliant on them for help. This help formed a major component in her habitual pathways of engagement. In a bigger school, exclusive help was not possible, nor were the teachers encouraged to help her because of her behaviour. The teachers were frustrated with Ruth because of her disruptive, negative behaviour and lack of engagement in the mathematics. The teachers' evident frustration resulted in Ruth feeling they were angry when she could not do the mathematics. Certainly they did not seem willing to help her when she perceived she needed their help. She also knew they had, in general low expectations of her – they thought 'maths was not her thing'.

Ruth is similar to the other students in this chapter in some ways. Like Colin and Philip in Year 10, she had stronger social needs as she entered into secondary school. These social needs were not balanced by designated identities relating to a love of mathematics or reinforced by her parents. Like Philip and Robyn, Ruth, when she did engage, sought an instrumental understanding of mathematics. Compared to others, she was even more

interested in the correct answer than in knowing the steps of the process and displayed no mathematical integrity. Like Philip and Robyn, her macro-feelings were dependent on the teacher. Help was an important element of Ruth's pathway of engagement, but Ruth did not experience the same attention from the teachers that Robyn did in class. Ruth is similar to other students in the research class who were perceived as low in class. They also had strongly negative macro-feelings about mathematics and lower engagement skills. They adjusted their designated identities because they perhaps felt helpless to close the gap between their actual identities and their class placement identities. The gap was reinforced by these students' exclusion from the top group of mathematicians, class discussions, awards, teacher and classmate recognition and help.

## 7.5 Conclusion

This chapter explored Colin, Philip, Robyn, and Ruth's relationships with mathematics. This exploration highlighted that different factors were the motivation for each student. In other words, different factors influenced their designated identities and, ultimately, their doing of the school mathematics. Figure 7.16 shows which factors influenced each student. What is immediately clear is that Colin had three strongly motivating factors – his love of the subject, the importance he placed on mathematics as part of his life, and his class positioning. Robyn also had fairly strong motivating factors in her class placement, class positioning, and her parents. Philip's parents were the main motivating factor for his doing of mathematics, and Ruth did not have a strong motivating factor. Even though it is difficult to compare the strength of these factors, when Colin, Robyn, and Philip had a gap between their designated and actual identities, they seemed more motivated than Ruth to close that gap. They had more need to succeed in mathematics, and this affected their motivation to engage in the subject.



**FIGURE 7.16** Motivating factors for Ruth, Robyn, Philip, and Colin

The factors in Figure 7.16 were the students' primary motivators to do the mathematics, but other elements of their relationship with mathematics also affected their engagement in the subject. Colin's positive views and feelings of mathematics, his strong mathematical knowledge, and, as part of his habitual pathways of engagement, his valuable engagement skills enabled him to, in general, meet his designated identities through full engagement.

Philip experienced tension between his designated identities because of his expectations of having both a fun, easy time and satisfying his father. He also had limited engagement skills, negative macro-feelings, and strong social needs, all of which affected his engagement in mathematics. Robyn made a lot of effort in mathematics to close what she perceived to be a large gap in her designated and actual identities, but her mathematical knowledge was low, her macro-feelings were not positive and, she had inadequate engagement skills. Ruth perceived she received a lack of support from her teachers, she had poor engagement skills, intensely negative macro-feelings about mathematics, and strong social needs. She rarely engaged, even at a superficial level, in the mathematics.

The students each interpreted the context of a mathematical situation in unique ways because of their relationship with mathematics. Furthermore, when meeting a mathematical task, the students ascribed different meanings to it because of this relationship (see Figure 6.6). At the beginning of Colin's engagement in a task, he was already feeling confident about his ability to succeed, and usually felt the task was worthwhile and enriching. Philip, at the beginning of the task thought he could probably do it, but often felt that he could not be bothered. Robyn, when faced with a mathematical task, was already anxious about her ability to do it and

anxious that she would receive yet more evidence that mathematics was “not her thing”. On the other hand, Ruth felt unprepared to engage and was usually not interested in the task’s outcome.

As the students engaged in the task, depending on the current context, and their habitual pathways of engagement, the students received evidence about whether or not they were meeting their expectations. They ascribed meaning to this evidence depending on their negotiation between the elements of their relationship with mathematics. When Colin’s expectations of success were not met, he persevered, changed his strategy and he did not question his mathematical ability. When Philip experienced difficulty, he was more likely to give up, but knew that he could have had more success if he had persevered. Robyn grew dismayed when she experienced failure to meet her expectations in a task because she had tried hard to compensate for her lack of ability in mathematics. When Ruth experienced difficulty, this was expected and reinforced her perception of her lack of ability and that there was no point in trying. In this way, the students each negotiated the meaning of their mathematical experiences.

The students’ relationships with mathematics changed because of the meaning they attributed to their unique experiences and performance outcomes. Over the two years of the research, Colin’s designated identities became more achievement and less enrichment oriented, and school mathematics became further distanced from his view of mathematics as a discipline. Philip’s journey showed how he began to balance better his identities to decrease the tension he experienced. Changing classes at the end of Year 10 allowed Robyn freedom from constant comparisons to classmates considered to be in the top group. Her designated identities also changed from needing to be in the best group of mathematicians to meeting the expectations of NCEA. From the middle of Year 10, Ruth considered herself unable to catch up on the mathematics, and she adjusted her designated identities as a way of closing the gap. She disengaged further from mathematics, and this disengagement led to non-participation.

Interesting contradictions and tensions were found during the exploration of the students’ journeys. Colin’s view that “nerds no longer existed” was contradicted by the others’ views of a mathematician as a nerdy figure of fun. Colin described a mathematician as a normal person. Anyone could be a mathematician, according to Colin, yet he enjoyed feeling special and unique from other people because he had a “thing” for mathematics and enjoyed the subject so much. He knew he was not “normal”. Philip knew that he needed to work hard, and

study more, but because of the tension created by his strong social needs he did not engage fully in the mathematics. Even for the end of year examination, when he was very nervous, and knew he needed to do well because his father would see the results, he did not spend much time studying. Robyn included achieving in the top group of mathematicians in her designated identities, yet had low expectations of her ability. These contradictions demonstrate that students are complex and their different performances and experiences cannot be associated directly with the elements of their relationships with mathematics.

This chapter has illustrated the unique qualities of each student's mathematical journey. The next chapter will provide a summary of the research and present recommendations for teachers and educators. It provides guidelines to enable teachers to get to know their students better, to understand the varying emphases on different elements of their learning processes and aims to recommend how teachers can anticipate and respond – indeed help the students to become resilient to changes in their own mathematical journeys.

# CHAPTER EIGHT: Discussion and Conclusions

In this research, the mathematical journeys of adolescents were explored by gathering a wide range of data, including the perceptions of 31 students over a two-year period. As described in section 1.3, 13-14 year old students in New Zealand are at a crucial stage in their mathematical education because it is just before mathematics becomes non-compulsory at school. Research into mathematical affect (reviewed in Chapter Two) has gone some way to understanding how students' feelings and emotions are connected to their mathematical learning. I wanted to further this understanding and also make the connection between students' feelings and their decisions about whether or not to continue participating in mathematics after it was no longer compulsory. These aims informed my research questions, which are re-stated from section 1.6, below:

This research seeks to investigate the mathematical journeys of a class of adolescent students in New Zealand by exploring the following questions:

1. What is the nature of students' relationships with mathematics?
2. How are these relationships associated with mathematical learning?
3. How do these relationships change over time to form mathematical journeys?

Affective research in mathematics education has begun to investigate students' affect and identities together (e.g., Frade, Roesken, & Hannula, 2010). In this research, the link between students' affect and identity has been extended. Affective literature in mathematics education (e.g., DeBellis & Goldin, 2006; Malmivuori, 2006) led me to view students as having a relationship with mathematics, of which their feelings are one aspect. The research into affect generally focussed on an individual's construction of knowledge, although some researchers incorporated social interactions into their view of students' mathematical learning (e.g., Hannula, 2006). Identity work in mathematics education has contributed to my understanding that learning is a social practice, socially and culturally constituted. Reviewing the research into students' identities (Chapter Three) guided me in investigating students' relationships using Sfard and Prusak's (2005a) narrative perspective of identity. They viewed identities to be a form of communicational practice – dynamic and situated in the current context.

In this chapter, the limitations of the current research are noted (section 8.1). The research questions are then answered in sections 8.2, 8.3, and 8.4. I then consider the implications of the research for mathematics teaching (section 8.5), suggest possibilities for further research (section 8.6), and conclude with final remarks (section 8.7).

## 8.1 Limitations of the research

There are a number of limitations in this research relating to the representativeness of the participants, and the difficulties in developing themes from discrete glimpses of the students' journeys. My bias in designing, conducting, and reporting the research is also acknowledged.

All of the students identified themselves as New Zealand European. Classrooms in New Zealand are rarely ethnically homogenous, and this classroom is therefore not representative of New Zealand society. Despite this, the findings indicated similarities in the views and feelings to students in other classrooms both in New Zealand (e.g., Averill, 2009) and in classrooms across the world (e.g., Boaler, 2002b).

My data-collection techniques improved as the research process continued and this may have affected some of the earlier data that was collected. The third column analysis described in section 4.5.1 was a good system to reflect on this. For example, soon after the research period began, when Bridget talked about mathematics being fun (section 5.2.4), I asked "Did you learn anything?" Bridget replied "Uhh ... not really" (Bridget<sub>InterviewYear10</sub>). I may have got a more elaborate answer if I had asked, "What did you learn?"

When the students articulated their consciously felt relationship with mathematics, often their words reflected their 'true' feelings. For example, when Colin spoke of loving mathematics, his whole face lit up and his voice was excited and full of energy. However, the students' stories were sometimes the stories they wanted me to hear. The students may have altered their responses and discussion because of their awareness of my role as a researcher/teacher or their discomfort with the research process. For example, they were all very quick to say how important mathematics was for getting a job later in life. It was only on further probing that their argument for this broke down somewhat (section 5.2.2). Furthermore, as discussed in section 6.2.3, these adolescents were socially focussed and were constantly making comparisons between themselves and others. This awareness of classmates may have affected their written feedback and personal journey graphs, which were completed in a group

situation. For example, in section 6.3, Corrina<sup>(InterviewYear10)</sup> said she wanted a seating arrangement, and then said “I shouldn’t be saying that”. Even in their individual interviews, the students sometimes described their idealistic thoughts or the “right thing” socially rather than describing their real thoughts.

Everyone always says augh, I don’t like maths, but there’s not anything actually wrong with it. [They say that] because it’s cool (Susan<sup>GroupInterviewYear11</sup>).

Philip’s responses to questionnaires often seemed to depend on whom he was sitting next to, as responses from the surrounding friends sometimes showed clusters of similar results. Moira and Ruth, on two occasions, had identical answers and doodles on the side of the paper.

This research relied on the students’ ability to articulate what they were experiencing. Students in this research were sometimes not willing or able to describe or explain their feelings or behaviour in any depth and needed prompting, sometimes to little effect. There were resulting difficulties in interpreting their responses. Students’ mercurial and transitory micro-feelings were particularly difficult to capture. Furthermore, the students’ unconscious and preconscious selves meant that students were simply not aware of some of the internal affective processes going on. The findings presented in this thesis were limited by these constraints.

The students came from an achievement class, which is a limitation in terms of the interpretation of the results. While the students were chosen for that class on the basis of their written English, and not their mathematics, they were all considered average or above average students in mathematics. Therefore, in this study, there is not a full range of mathematical abilities. For example, none of the case study students could have been considered to be weak in mathematics to begin with. Indeed, the results of this research, which relate to students’ competitiveness and issues surrounding the top group, do allude to these students being from the upper range of mathematical achievement. This group of students had experienced much success throughout their schooling. For students who had experienced intermittent or continuous failure during their school years, although the elements of their relationships with mathematics may be the same, these relationships may have been very different.

These limitations presented a challenge throughout the research process. The design of the research methodology (Chapter Four) goes some way to alleviating these concerns. However,

research in mathematics education that is related to students' mathematical affect will continue to be challenged by these aspects.

## **8.2 What is the nature of students' relationships with mathematics?**

There was some consistency among affective researchers in Phase Three (section 2.3) in the notion that students had mathematical cores – stable, internal structures that related to the subject of mathematics (DeBellis & Goldin, 2006; Malmivuori, 2006; Op 't Eynde et al., 2006). Many of the conceptions of a mathematical core in the affective literature were concerned with individuals' constructing the elements through individual processing of their learning experiences. These elements included:

- Mathematical content knowledge;
- Strategies for accessing and using that content knowledge;
- Beliefs about mathematics, mathematics teaching and learning, the context and about themselves in relation to mathematics;
- Related needs of autonomy, competency, and social belonging;
- Global affects;
- Meta-knowledge, habitual affective pathways and behaviours in mathematics.

Identity research in mathematics education similarly talked about students' mathematical identities. There was less agreement about what this 'mathematical identity' contained – though identity was generally considered to be the meanings of the students' experience of membership (Hodge, 2006). Identity research has contributed to my understanding that a student's identity is not an object and it cannot be captured, as such, in research (Sfard & Prusak, 2005b). Rather, students' identities are dynamic because there is constant reinforcement and change as students experience mathematics (Boaler et al., 2000b). Combining affective research in Phase Three with identity research provided a more elaborated view of affect in mathematics education.

In the current research, a grounded theory approach was used to identify the elements of the group of students' relationships with mathematics. Similarly to the concepts of students' 'mathematical core' or 'identities', in investigating the students' mathematical journeys in this research, these students described complex and dynamic relationships with the subject of

mathematics, which formed as they experienced school mathematics and interacted with classmates, teachers, and their families. These relationships were found to have five elements (section 4.5.2).

1. Views of mathematics
2. Mathematical knowledge
3. Macro-feelings
4. Identities
5. Habits of engagement

These elements emerged from examining the group of students' perspective of their mathematical learning, yet there are some similarities between these and the components of a student's mathematical core, described in the previous research. Both include elements relating to knowledge, beliefs, affect, expectations, and habits. Both include aspects of change and stability. Each element of students' relationships with mathematics is detailed in the following sections. The similarities and differences between these relationships and a student's mathematical core are discussed in the following sections.

The elements that emerged in the analysis of the students' relationships were each important in themselves. They individually influenced the students' learning and contributed to their unique mathematical journeys. Furthermore, together these elements formed the students' relationships with mathematics and provide the context within which they engaged in each mathematical task. This unifying of the individual elements was important in this thesis to enable the students' mathematical journeys to be analysed and compared. Also, this unifying was important because it allowed students' journeys through mathematics to be analysed and compared at both the general and the specific (or the macro and the micro) levels.

### **8.2.1 Views of mathematics**

In the affective literature, mathematics-related beliefs were conceptualised as part of a student's mathematical core. In this thesis, a student's 'view' was conceptualised as a subjective conception a student held to be true – similar to Op 't Eynde et al.'s (2002) conception of a belief – and it was also seen as socially constructed, situated in the context of the mathematics classroom, and dynamic.

The students' views about school mathematics that emerged from the analysis were related to the subject's importance, its nature, and their perceptions of the subject as difficult and boring. These are similar to the beliefs about mathematics that other researchers found (Kloosterman et al., 1996; Op 't Eynde et al., 2002), but these categories emerged from the students' perspective, rather than in response to prompts in a questionnaire.

The students' views about the importance of mathematics mainly developed because of their interactions with their families. As discussed by Lange (2008a), home environments had an impact on students' views in the classroom. The parents involved in the current research talked about their views about mathematics, mathematics learning, and teaching, and, as in the research of Graue and Smith (1996), parents and students sometimes described mathematics using shared ideas and language. On closer inspection however, although parents emphasised the importance of success in the subject, the students' view of mathematics as an important subject was tenuous. The students were aware their families considered mathematics to be important, but experienced tension as they negotiated between their parents' views and their experiences in the classroom. Philip's case study (section 7.2) illustrated this tension.

Through their drawings and later discussions of mathematicians, the group of students showed that continuing in mathematics was, for many of them, neither attractive nor viable, and they distanced themselves from mathematics in their future. These findings were in some contrast to the students' responses to questionnaire prompts about the usefulness of mathematics both in this research and in the beliefs' research (Kloosterman, 2002). Like the students in Sullivan et al.'s (2006) research, these students seemed unconvinced that they needed mathematics as a skill in their lives (section 5.2.2). With the exception of Colin (section 7.1), the group viewed mathematics as a subject to be taken at school and left there. Sullivan and McDonough (2007) linked students' motivation with the extent to which they connect current schooling with future opportunities or their possible selves, and indeed, the ambiguity of students' views about the importance of mathematics had important implications for their decisions to continue their participation in mathematics. The ambiguity of students' views was interesting when individual students' views and participation decisions were compared. For example, Frank and Dawn (section 5.2) had similar macro-feelings about and confidence in the subject of mathematics, and similar views about its nature. Dawn thought the subject was both important and useful, whereas Frank did not. Dawn went on to pursue mathematics at some level, and Frank did not to pursue mathematics further than the compulsory years. This highlights the importance of affective research using more than one

tool in seeking students' views about the nature of mathematics and the implications of these views.

As in other research conducted in New Zealand (e.g., Young-Loveridge et al., 2006) and internationally (e.g., Schoenfeld, 1992), the students generally had an instrumental view of mathematics (section 5.2.1). For them, mathematics consisted of a large set of rules to be learnt "off by heart" to solve problems with a single, correct answer. The students talked about "being able to do the mathematics" and only rarely discussed the need to understand why the rules worked. These views developed from their experiences in the mathematics classroom. The students copied down notes and examples of rules, and spent the largest proportion of their lesson time answering short questions from the textbook to practise the rule they had just been taught. The students did not construct their own rules and were rarely exposed to alternatives. They described their mathematics lessons as having a routine which is familiar to other descriptions of traditional classrooms (e.g., Boaler, 2002b).

All of the students viewed mathematics to be a unique school subject. Other researchers have discussed this only briefly in mathematics education. For example, Kloosterman (2002) described mathematics content and pedagogy to be unique to the discipline. Richardson and Woolfolk (1980) described mathematics as having more precision, logic, and emphasis on problem solving than other subjects. The students in this research were explicit about differences between mathematics and their school subjects. Compared to mathematics, other subjects had more variety in their routines and used methods unseen in mathematics classrooms such as role-plays, small group work, class discussions, posters, and debates. This lack of variety, the individual work in mathematics and the constant revision of mathematical content contributed to the students' view that mathematics was a boring subject and, in fact, more boring than their other subjects. Although Boaler (2002b) suggested students' discussions of boredom could be part of their social role, there was little evidence that the students were using boredom as an adolescent excuse. Rather, their discussions about their boredom were restricted to their frustrations about the routines they encountered in school mathematics. Boredom is an example of a less intense emotional state which has not been adequately accounted for in models of the affective domain such as McLeod's (1992) or in mathematics education research. In this research however, with the exception of Colin, the students frequently discussed boredom (section 5.2.4), and boredom was a critical factor in their macro-feelings about the subject and their decisions about further participation. For

example, Peter directly related his hatred of mathematics to boredom and his decision to discontinue in the subject.

As in Shannon's (2004) research, many of the students also considered mathematics to be more difficult than their other subjects. The students were quite specific about this difficulty. They were often overwhelmed by the number of rules they perceived they were required to remember and be able to use because of the cumulative nature of mathematics. In other subjects, the lessons were more stand-alone and the students perceived they could engage to a greater extent without knowing the content. In mathematics, a large proportion of each lesson was spent working individually. The students were expected to spend more time thinking and concentrating. In other subjects, there was more lesson time spent listening, discussing issues as a class or in groups, or writing notes. Furthermore, mathematics was taught at a faster pace than the other subjects and was perceived as more difficult to catch up on when the students experienced difficulty, had disengaged, or had been absent. The students were constantly making comparisons with others' progress and achievement. Robyn (section 7.3) was one student whom this particularly affected. When the group of students experienced difficulty, it was more obvious in mathematics than in their other subjects, because of the nature of the subject. These are findings little discussed in other mathematics education research and they are important because they each contribute to the students' overall perception of mathematics as a difficult subject, which the students linked to their participation decisions.

Although some students enjoyed the challenge of mathematics, as in Colin's case (section 7.1), for most of the students, the subject's level of difficulty contributed to their negative feelings about the subject of mathematics. Similarly to Zan and Di Martino's research (2007), all of those in the group with a low confidence in their mathematical ability disliked mathematics. Furthermore, some of the students who were confident in their ability also disliked mathematics because of their views of the subject. For example, Peter, who disliked mathematics enough to stop taking the subject, was in the top group of mathematicians and was very confident in his ability. Researchers in the affective domain cannot assume that students who find the subject easy are those who also like the subject.

This research not only has provided a contemporary, if familiar, picture of a group of students' views of mathematics, it has explored some of the implications of that view in terms of the interaction between other elements of their relationship with mathematics, but also how the students' view of mathematics impacts their mathematical journey.

### **8.2.2 Mathematical knowledge**

Students' mathematical knowledge emerged as an element in students' relationships with mathematics. Mathematical knowledge is generally defined as the facts, symbols, concepts, and rules that constitute the contents of mathematics as a subject field, as perceived by the community of mathematicians (Op 't Eynde et al., 2002). Similarly, when the students talked about mathematical knowledge, they usually meant the rules they had been taught in order to solve the mathematical tasks (section 5.2.1). Differently to Op 't Eynde's (2002) conception of knowledge, the students' knowledge was co-created by the community of the classroom, and was therefore likely to be very different to how mathematicians might conceive of mathematics. As discussed by Schoenfeld (1992), the students' conception of knowledge was related to the way the students were taught mathematics – as a series of rules, given with specific examples, and reinforced by practice of that rule from the textbook. Therefore, this research endorses Holland et al.'s (1998) view that it is the practices of learning mathematics that define the knowledge that is produced.

Sullivan et al. (2006) noted that successful engagement in mathematics required the student to have the necessary mathematical knowledge, and similarly, in the current research, the way a student engaged in a mathematical task was influenced by their knowledge. The students did not have experience in constructing the rules for themselves and this meant to do the mathematics, the students needed to know the rules off by heart. Their ability “to do” the mathematics was, for the students, dependent on their memory of the rules, and the students perceived they each had different levels of mathematical knowledge – different levels of “knowing” the content.

### **8.2.3 Macro-feelings**

A student's macro-feelings – their overall feelings about the subject of mathematics – emerged as an important element in students' relationship with mathematics. These are similar to DeBellis and Goldin's (2006) conceptualisation of 'global affect', and McLeod's (1992) notion of a student's 'attitude' to mathematics. Macro-feelings are different, however, because they are from the students' perspective, rather than an independent observer. The changes in them have been considered over time, rather than as a snap-shot of students' affect at a certain stage in their journey. In McLeod's (1992) conceptualisation, attitude was considered to be stable over time compared to transitory emotions. Similarly, the students' macro-feelings in this research were relatively stable compared to their micro-feelings – their

feelings experienced during an individual task (discussed in section 8.3) – but did change throughout their journey (discussed in section 8.4).

As found in other research (e.g., McLeod, 1994), the majority of students viewed mathematics neutrally or negatively (section 6.1.1). Students disliked the subject because of their view of it as a boring and difficult subject. What has not been found in other research, however, is that the students viewed mathematics to be a unique subject because of the number of students who disliked it. This has implications for students' participation decisions in school mathematics.

McLeod (1992) described an attitude as being a moderate affective response in contrast to more intensely felt emotions. In contrast to this, although negative macro-feelings were prevalent, students' experienced a range of macro-feelings of different intensities, which were both positive and negative. Students with positive macro-feelings about mathematics were meeting or exceeding the expectations associated with their designated identities. The students talked about experiencing a range of neutral, positive, or negative macro-feelings that had a range of intensities. For example, the students described feeling both intensely and mildly bored about the subject of mathematics. This has important implications for mathematics education research because much of the affective literature has dealt with students' more intense affective responses. Yet, this research has found that less intense affective responses can accumulate over time and contribute to students' negative macro-feelings about mathematics. These students may be just as likely to discontinue with mathematics as a student who experiences high-intensity mathematics anxiety. Also, if two students are both experiencing boredom of a reasonably low-intensity – because students' relationships with mathematics are unique, these feelings of boredom have different implications for the student in terms of their mathematics learning. For one of the students, it might be a micro-feeling relating to a particular lesson that passes quickly. For another student, it might be the same feeling they have had for many weeks.

#### **8.2.4 Identities**

Sfard and Prusak (2005a, 2005b) defined identities as significant, reifying and endorsable stories told about the students. Students' identities were collected in the current research using mainly interviews and written responses. All of them were to do with the students' perceptions and expectations relating to their mathematical ability. The analysis of these

identities and the conclusions drawn from this analysis have extended Sfard and Prusak's (2005a, 2005b) ideas in a number of ways.

Sfard and Prusak (2005a, 2005b) divided students' identities into actual (e.g., I am bad at maths) and designated (e.g., I should be doing better in maths) identities (section 3.4). This research extends Sfard and Prusak's (2005a, 2005b) research by detailing the ways the parents, classmates, and teachers contributed to these sets of identities. Designated identities were defined by Sfard and Prusak (2005a) as stories students told about their overall expectations in mathematics, such as "I should do well in maths", and the way they saw mathematics as contributing to their future life. The current research reflects the complexity of the students' expectations. As in Sfard and Prusak's (2005a, 2005b), parents told stories of expectations of participation in mathematics courses, engagement, achievement, and how mathematics contributed to future careers. The students' designated identities were sometimes re-voiced versions of their parent's expectations, as in Philip's case (section 7.2). Some of the students' designated identities related to their expectations of class placement (section 6.2.2). In the achievement class, the students had the perception that they were taught at a faster pace, they were expected to achieve to a high level and needed to be able to understand the mathematics quickly. This is similar to Boaler, Wiliam and Brown's (2000a) research, which investigated students' experiences of ability grouping, and found 'top-set' students were required to learn at a pace incompatible with understanding. Students also had designated identities to do with being able to work and achieve to the level of their expected positioning within the class (section 6.2.3). The teachers reinforced the expectations of the class and had expectations of individual students' achievement and class positioning, potentially contributing to students' sets of designated identities. Research directly relating to students' achieving to their expected positioning in class has not been found in affective research. Even if students are working on mathematical tasks designed for individuals, they are constantly comparing their performances and progress with others.

Actual identities were stories relating to the students' view of their ability in mathematics, such as "I am good at maths". Whereas Sfard and Prusak's (2005a, 2005b) research has relied on the stories that the students and others told about the students, the richness of this data set showed more clearly how these influences operated on identity stories. During their mathematical journey the students collected evidence of their ability through their experiences in the mathematics classroom – through interaction with, classmates, families, by the class they were placed in, where they were positioned in the class, assessment results, prizes, and

through their doing of mathematics. These formed the stories floating around from which students produced their identity narratives.

Many of the students had negative macro-feelings about mathematics because they had persistent difficulties in fulfilling their designated identities. These macro-feelings were therefore because of persistent gaps between their actual and designated identities. For example, Robyn (section 7.3) had a large gap between her actual and designated identities. Her expectations were very high and she persistently did not achieve to the level of these expectations. Her interpretation of her progress contributed to her low confidence in her ability in mathematics.

The gap between students' actual and designated identities could be positive, neutral, or negative. Indeed students were found to experience a range of affective responses to mathematics at different intensities when there was a gap between their identities, depending on their relationships with mathematics. As well as negative feelings, the students described instances of positive feelings when they exceeded their expectations. In this case there was a, usually brief, positive gap. For example, Lola described her best mathematics experience to be when she got Excellence as a test result when she was not expecting it. This extends Sfard and Prusak's (2005a, 2005b) discussion about gaps between students' actual and designated identities, and means researchers in this domain need to seek the meaning of positive and neutral experiences, as well as negative ones.

### **8.2.5 Habits of engagement**

'Engagement' refers to the students' involvement in the mathematical activity of the classroom and their commitment to learning the mathematical content (section 5.1). Like the research of Malmivuori (2001) and Goldin (2004), there was some evidence that the students developed habits of engagement, which formed part of their relationship with mathematics. For example, Ruth usually avoided mathematics, instead talking socially or texting on her phone (section 7.4), whereas Peter completed the mathematical tasks as quickly as he could to get them over with (section 7.1.2). In some detail, the students also described the pathways they usually took when attempting a mathematical task – their pathways of engagement – a term adapted from Goldin's (2004) use of the term 'affective pathways' (section 5.1). Goldin used affective pathways in a more detailed way to describe individual's dynamic problem solving processes at a task level. The analysis in this thesis used it in a more macro sense to describe students' habitual pathways of engagement; although the way student's described

their pathways of engagement during the algebra were the catalyst of this (section 6.1.2). The pathways the students described could be typified as avoidance, superficial engagement, and full engagement. If a problem initially looked hard, some students avoided doing the problem altogether – disengaging from the mathematics. Other students only made a superficial attempt to solve the problem, giving up when they experienced difficulty. A few students described full engagement in mathematical tasks, persevering and often using a variety of strategies.

In analysing the different pathways of engagement that Colin had, and then comparing Colin's engagement with the other students in the class, a set of engagement skills emerged. These skills, detailed in Table 7.3 in section 7.1, were perseverance, integrity, intimacy, independence, concentration, and reflection. Researchers in the affective domain have discussed these concepts or similar ones to various degrees. DeBellis and Goldin (2006) talked about a student having affective competencies, which included the components mathematical intimacy – an emotional attachment with mathematics, and integrity – a commitment to searching for mathematical truth; terms which have been adopted in this research. Hannula (2006) talked about students' need for autonomy and their self-regulation and how this could be conscious or unconscious. Students' concentration skills have not been discussed much in mathematics education research. Outside this domain, Yair (2000) talked about the students' need to focus on the instruction.

In this research, the students had engagement skills of different levels of effectiveness. Although many of their skills were effective in their daily routine of answering questions individually from the text-book, they were ineffective over the course of their mathematical journey, if they needed to catch up with mathematics or close the gaps between their actual and designated identities. Further comparisons between students are made in section 8.3.

The students' overall engagement in mathematics was influenced by other elements in their relationship with mathematics in complex ways. Beliefs' researchers often assumed students' beliefs were linked to students' achievement or their mathematical learning (Kloosterman et al., 1996). In the current research, the students made direct links between their views of mathematics and their doing – their engagement in mathematics. Students who viewed mathematics as a useful and important school subject, were more likely to engage in it to a fuller extent – these are similar to Sullivan et al. (2006) findings, which described students' engagement and motivation in mathematics as vulnerable when they were unconvinced about

the value of mathematics in their current or future lives. All 31 of the students directly associated their macro-feelings with the way they engaged in mathematics. If they felt positively about mathematics overall, they engaged in the mathematics to a greater depth. In other words, they were more involved in the mathematics, and were more committed to their learning. They concentrated more, discussed the mathematics with others, and did more work. If the student disliked mathematics, they did not generally become as involved in the subject.

The students' generally viewed mathematics as a boring and difficult subject. Boredom made the students feel tired and unhappy. It reduced the engagement of the students in terms of the amount of work they did, the depth to which they did the work, their level of perseverance and the time the students spent socialising. When students perceived mathematics to be an important subject, they viewed engagement in the subject to be necessary because of the nature and difficulty of the subject. For these students, this helped to balance their loss of motivation to engage that they experienced because of the boredom. This finding emphasises the problems when researchers investigate just one aspect of students' relationships with mathematics. It is the interaction between the elements of a students' relationship that contribute to students' engagement and participation in mathematics.

Sfard and Prusak (2005a) wrote that learning took place to close the gap between a student's actual and designated identities. Similarly, the students in this research were motivated to engage in the mathematics because they wanted to meet the expectations created by their designated identities. The size of this gap affected the way students engaged in the mathematics. Students with a small gap between their identities, such as in Philip's case (section 7.2) were more inclined to engage in the mathematics to close the gap. For Corrina and Ruth (section 7.4), the gap was too large. They felt unable to meet the designated identities relating to class placement, they adjusted their designated identities as a result, and disengaged with mathematics. This is an important extension of Sfard and Prusak's (2005a, 2005b) work. Rather than negative feelings resulting in learning, negative feelings also may result in adjustments to designated identities. This is likely to have an impact on students' desire to continue with mathematics.

One of the themes to emerge from analysing students' habits of engagement was the theme of help-seeking. Students' help-seeking is rarely discussed in mathematics education. Students' help-seeking was affected by their perceptions of their own mathematical ability, which classmates they were seated near, their perception of their parents' ability or availability to

help them, and their relationship with the teacher. Interestingly, the students who were the most confident in their ability asked for help frequently, often seeing help-seeking as an opportunity to discuss the mathematics. On the other hand, many students in the class either did not ask for help perceiving it to be a clue that they were experiencing difficulty with the mathematics, as seen by their classmates or teacher, or because they felt they would not understand the answer anyway. Others asked for help as soon as they became confused with a problem because they did not value the need to think more deeply about the problem. They were not interested in seeking understanding or working independently, but wished to avoid the negative feelings associated with confusion. These students were dependent on help and this was perhaps linked to their instrumental understandings of mathematics. When students have only instrumental understanding of the rule, if they do not know which rule to use, their only solution is to wait for the teacher's help or to ask a classmate. If this is not forthcoming, then there is no point in continuing. Students' discussions on help-seeking were valuable for understanding the complexities of the students. For example, Bridget gave up on difficult tasks after only superficial engagement (section 5.2.3) and often talked socially in mathematics (section 5.2.5). On the other hand, she felt she needed to talk about the mathematics to learn (section 6.3). Despite this, she rarely asked for help because she did not have good experiences when she asked the teacher (section 5.2.5), and often felt uncomfortable asking for help from or discussing the mathematics with her peers (section 6.3).

### **8.3 How are students' relationships with mathematics associated with learning?**

The second research question was related to how students' relationships with mathematics were associated with learning. Barton (2003) advised that research which explored affect also needed to explore the associations between affect and learning. Indeed, researchers in the affective domain rarely defined what 'learning' is, often assuming students' achievement to be an indicator of learning (e.g., Norwood, 1994). Researchers in Phase Three of the affective domain (section 2.3) did link affect with learning processes (DeBellis & Goldin, 2006; Malmivuori, 2006; Op 't Eynde et al., 2006). They viewed affect as an essential feature of learning rather than a side effect of cognition (Hannula et al., 2004). Students' mathematical cores changed as new learning situations were experienced (Malmivuori, 2001). As discussed in Chapter Two, however, there are few examples where students' perspectives of how their feelings are associated with learning have been explored.

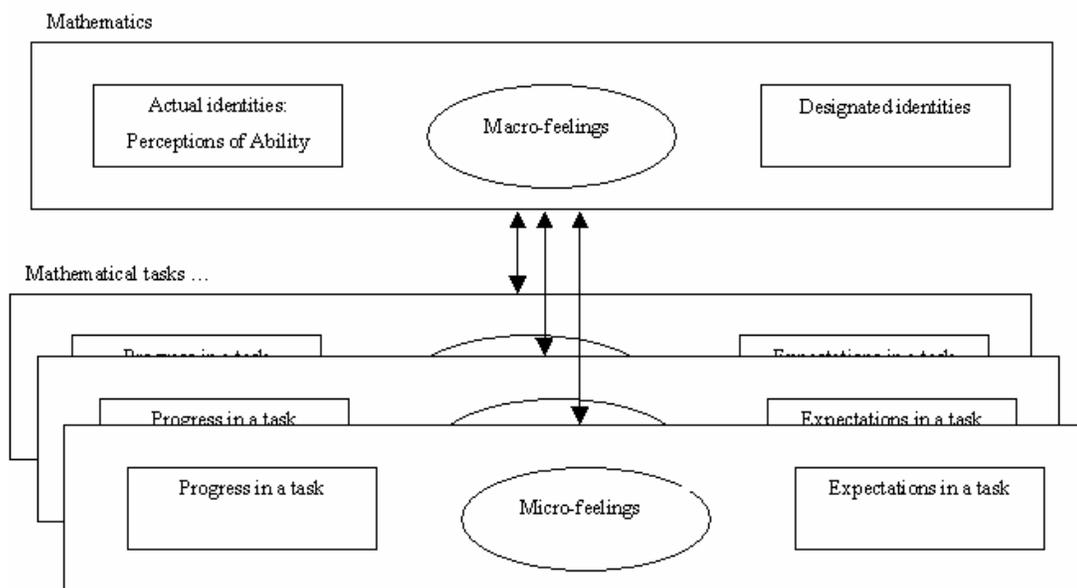
The students in the current research, when they referred to learning, seemed to assume that, if they engaged in the mathematics by completing the mathematical tasks correctly, learning would take place. Indeed, as in the research of Yair (2000) and Williams and Ivey (2001), they often discussed their ‘doing’ synonymously with ‘learning’, and as the outcome of a particular situation (section 5.1). This view endorses Boaler and Greeno’s (2000) notion that learning is participation (referred to as engagement in this thesis) in the practices of the mathematics classroom.

Many of the affective researchers differentiated between talking about affect at both a subject-level and the task-level. Goldin (2004) differentiated between global and local affect (section 2.3), and McLeod (1994) differentiated between attitude and emotions (section 2.2). Sfard and Prusak (2005a, 2005b) generally discussed students’ identities at a broad level. This research extends these ideas about affective research in mathematics education and investigated students’ relationships with mathematics at both a subject-level and a task level. In other words, this research considers students as having a relationship with the subject of mathematics overall, and also considers how this affects students when they are working on a specific mathematical task. Through engaging in the practices of the mathematics classroom, when a student engaged in a mathematical task, they constantly negotiated between their relationship with mathematics and the current situation. Depending on their views of mathematics, students had different perceptions about a specific task’s importance, different expectations of its difficulty and different expectations of boredom. At the moment of engagement students had unique identities and macro-feelings about the subject of mathematics.

The students in the current research also distinguished between two types of feelings. They defined ‘macro-feelings’ as their overall feelings about the subject of mathematics, including general like or dislike. They also described ‘micro-feelings’ as the relatively transitory emotions the students’ experienced when they engaged in a mathematical task. Distinguishing between macro and micro-feelings when analysing these data was a useful way to consider both how students’ feelings about mathematics impacted their learning and engagement in the mathematical classroom, and how they impacted students’ mathematical journeys. When they began a new mathematical task, the students had connected it to similar tasks that they had experienced previously and therefore had macro-feelings about the topic and expectations about its level of difficulty. Students’ macro-feelings about the subject of mathematics were

part of the context for their micro-feelings. Students who enjoyed mathematics overall were less likely to experience negative micro-feelings when doing a task. Students with overall feelings of dislike were more likely to feel negatively about the task. Robyn’s overall feeling of despair in mathematics, for example, led to feelings of anxiety and worry when she faced a new mathematical task (section 7.3). Students’ micro-feelings were unique in their nature, intensity and duration depending on the students’ appraisal of the situation according to their unique relationship with mathematics.

In the current research, students were also constantly negotiating between their identities at a subject level and their expectations and progress at a task level. Students’ perceptions of how good they were at mathematics (their actual identities) provided the context for localised perceptions about whether they could do a task based on their progress (see Figure 8.1 below). In other words, students who thought “I am good at maths” also thought “I will be able to do this task”. Expectations of overall success in mathematics (designated identities) provided the context for localised expectations at each moment of engagement in the mathematics. In other words, “I should be good at maths”, provided the context for, “I should be able to do this task”. Sfard and Prusak (2005a) described designated identities as less context dependent than actual identities. In this research, students’ identities – both actual and designated were entirely dependent on the unique context the students were situated in because of the constant negotiation between their relationship with mathematics and the immediate mathematical task. How students’ identities and feelings operated at a subject level and a task level is considered in Figure 8.1.



**FIGURE 8.1 Identities and feelings at a subject and task-level.**

The current research found that it was the complex negotiation of meaning between students' current relationship with mathematics (section 8.2), and their individual interpretation of the context of the moment, which influenced students' engagement in a mathematical task. Researchers in mathematics education have talked about various ways the context interrupts students' learning, but in the affective domain, social factors and the role of the context are often not mentioned (section 2.3). In Bloomer and Hodkinson's (2000) view, context needs to be seen as more than a physical space where learning is located. Rather, it is constructed in the course of social interaction. The idea of context is interpreted in a broad sense in this research and provides a valuable elaboration of how affect is influenced by the context in which the student is engaged. When the students engaged in the mathematics, they were situated in a unique context of the moment (section 5.1). This moment of engagement occurred at a specific stage in the lesson, on a particular day and time of day, at a particular stage in the teaching of the current topic, and at a particular stage in the school year and in the students' journey through life. The mathematics teacher, the specific mathematics activity and the current social norms also formed part of the context of the moment. Aspects of the classroom's physical environment such as heating and lighting and seating arrangement further contributed. Classmates directly affected students' engagement through their social and mathematical behaviour. Students were also individually processing family or relationship issues, or were perhaps experiencing illness, depression or tiredness. These factors affected a student's engagement in each mathematical task. Students' individual and complex lives continued in the classroom. Rather than external factors that enabled or interrupted mathematical learning, students' lives were part of their learning of mathematics. This research has taken these factors into account more than other research into affect and identity (e.g., Boaler, 2002b; Malmivuori, 2006), by specifically linking the context of the moment to the affect experienced by the students. Furthermore, each student is considered to interpret the context of the moment uniquely. The way the student engaged in each mathematical task depended on this interpretation and their current relationship with mathematics.

Aspects of their current relationship with mathematics, the context of the moment, and their micro-feelings affected the students' engagement in each task in a complex way. During their doing of the task, students' micro-feelings were conditional on their progress. As shown in Figure 8.1, when a student perceived they were not meeting their expectations of success in the task, they experienced negative micro-feelings. Positive micro-feelings signalled that the

student was fulfilling or exceeding his or her expectations of success in the problem. This is similar to the DeBellis and Goldin's (2006) research where affect was conceptualised as meaningfully encoding information about a student's progress. Malmivuori (2006) described appraisal and self-regulatory processes as being activated by affect. In the current research, the students' motivation to engage came from their need to fulfil their expectations and to close any gap between these and their current progress. Their further engagement in the problem depended on the context of the moment, their habits of engagement and further negotiations with their relationship with mathematics. This process results in unique mathematical learning experiences and performance outcomes.

The students individually negotiated the meaning of learning experiences and performances. The meaning derived from this negotiation reinforced or altered components of the students' relationship with mathematics. Figure 6.6, in section 6.4, summarises this process. As a result of doing mathematics, the students talked about knowing more. The level of students' mathematical knowledge changed as they were exposed to more rules. In other words, the students' success or failure in the mathematical tasks contributed to their perceptions of their overall ability in mathematics and their future expectations. Continuing or significant lack of success in tasks contributed to students' negative macro-feelings about mathematics and lowered their expectations of future mathematical tasks. Students' views about mathematics and their habits of engagement were reinforced or changed. New learning experiences either reinforced their elements or, if sufficiently powerful or repeated often enough, altered them. Therefore, the elements of the students' relationships with mathematics developed through their engagement in the practices of the mathematics classroom.

There were two-way influences found between elements of students' relationship with mathematics and their experiences when doing a mathematical task. For example, section 6.1.2 describes the connection between macro and micro-feelings. As in McLeod's (1992) conceptualisation of the interaction between emotions and attitude, but from the students' perspective, macro-feelings provided part of the context for micro-feelings to develop. Students' micro-feelings also affected their doing of mathematics, and as a result of their engagement in the mathematics, further positive or negative micro-feelings were experienced. Micro-feelings, when significant or repeated, in turn, contributed to students' macro-feelings (section 6.1.2). Research in the affective domain needs to take account of this two-way process, rather than assuming that affect influences an indicator of learning such as achievement (e.g., Norwood, 1994).

Wenger (1998) wrote about each student having a unique identity which is socially and culturally constituted. Sfard and Prusak (2005a, 2005b), described identity to be the conceptual link between the collective and the individual. In the current research, students had a unique relationship with mathematics. Yet, the elements of this relationship were both collectively and individually constituted through participation in the shared practices of the mathematics classroom. For example, the students developed a shared set of designated identities relating to their class placement. They were in the achievement class in Year 10, so the students felt they needed to engage fully in the mathematics and have good classroom behaviour. They also perceived they were expected to achieve to a high level and be able to understand the mathematics quickly (section 6.2.2). They also interpreted these shared designated identities individually because of their perception of their class positioning. A student's views about mathematics can also be seen as both individually and collectively shared. The students generally had an instrumental view of mathematics. Like the students in Schoenfeld's research (1992), the students believed that a mathematical task should be completed quickly. This view is both constituted and reinforced by the socio-mathematical norms – the practices relating to mathematics - of the mathematics classroom (Yackel & Cobb, 1996). In this sense it is collectively shared. Each student's belief that a task should be completed quickly, however, is subtly different because of the student's negotiation of this with other elements of their relationship with mathematics.

The analysis of these data was first done at a class level (Chapter Five and Six) and then individual students' data were analysed (Chapter Seven). While not common in mathematics education, this approach was useful in understanding the class's relationship with mathematics from their perspective, in order to understand the context of individual student's relationship with mathematics. Furthermore, this approach meant the students' relationships with mathematics could continually be compared with each other and compared with those of the class.

Rather than just one tool being used to gather students' views of mathematics as was done in much of the beliefs' research (e.g., Kloosterman et al., 1996), a combination of metaphors, interviews, questionnaires, and students' drawings of mathematicians were used. This combination of research tools and the inductive analysis meant the students' views could be considered in detail in this research. The students' drawings of mathematicians and the metaphor prompts were particularly useful for gathering students' views about the nature of

mathematics. Similarly to Miller-Reilly (2006) and Buerk (1996), the students engaged fully in the task of producing metaphors. With some humour, the students completed the task industriously, and there was surprisingly little talk between them about their answers. The students seemed to enjoy this task, perhaps because it allowed students to safely express their feelings. Of course, not all students were willing or able to provide a metaphor for mathematics, again emphasising why a range of data collection methods was necessary. For an explanation of the identification of the following quotes, section 4.6.

I can't and don't picture maths as a type of food, or car, or building, because again in my opinion that's sort of weird. Maths is maths just like a car is a car or an apple is an apple (Nicola<sub>MetaphorsYear10</sub>).

Overall, the use of metaphors was a particularly powerful research tool, which generated many responses for later discussion in the student interviews. Joanna, for example, wrote the following in Year 10 in response to the metaphor work. Her interview questions were based around this written response.

If maths was food I wouldn't eat it! It would make me sick! ... If maths was a building it would fall down. For me, maths is most like manure ... because manure is disgusting, it's horrible, and it smells. So maths stinks. I have never looked forward to a class so I have never looked forward to seeing manure on a paddock either. Maths makes me bored, stressed, and tired. But when class is over it all feels happy again (Joanna<sub>MetaphorsYear10</sub>).

In particular, the metaphor exercise allowed students' views about mathematics and their feelings about the subject to be collected. By writing metaphors, the students may also have become more conscious of their own conceptions of mathematics and their feelings about the subject, broadening "mathematics to include language, imagery, and reflection" (Buerk, 1996, p. 27).

The level of detail allowed understanding to develop about what views the class commonly held, and what were individual variations of these views. This level of detail is rarely found in the beliefs' literature in affective research. The sameness and variation in the students' views meant the students could be compared to each other and to the class as a whole, as is necessary in research involving case studies (Strauss & Corbin, 1998).

Students' relationships with mathematics are associated with learning in complex ways. Students learn mathematics by engaging in the mathematics classroom. Their engagement is a negotiation of meaning between the context of the moment, the elements of their relationship with mathematics and their constant interpretation of their progress and performance in the mathematical tasks in front of them. These interpretations lead to changes in their relationship with mathematics, which over time, form their mathematical journey.

## 8.4 How do students' relationships with mathematics change over time?

As discussed in section 1.3, students choosing not to study mathematics to an advanced level is a persistent issue in mathematics education (Boaler & Greeno, 2000; Boaler et al., 2000b; Ma, 2001; Middleton et al., 2003). In the literature, students aged around 15 years were deemed to be at a critical point in their mathematical journey because that is when mathematics is no longer a compulsory subject at school (Leder et al., 2002). Out of the 31 students in the research, six chose not to participate in mathematics when it was no longer a compulsory subject. Table 8.1 shows the mathematics courses the students enrolled in.

**TABLE 8.1 Enrolment in mathematics in Years 11 and 12**

	Year 11	Year 12
<b>Academic stream</b>	<b>MAT101</b> Peter, Frank, Mark, Philip, Katrina, Susan, Nicola, Sean, Amanda, Jason, Colin, Robyn, Angela, Ben, Paul, Connor, Lola, Cheryl, Dawn, Alasdair, Jennifer, Tia, Joanna, Moira, Bridget, Saskia	<b>MAT201</b> Mark, Philip, Katrina, Susan, Nicola, Sean, Amanda, Jason, Colin, Robyn, Angela, Ben, Paul, Connor, Lola
<b>Non-academic stream</b>	<b>MAT102</b> Corrina, Ann, Jill, Ruth, Debbie	<b>MAT202</b> Corrina, Ann, Jill, Cheryl, Dawn, Alasdair, Jennifer, Tia, Joanna, Moira
<b>No mathematics</b>	Mathematics compulsory	Peter, Frank, Ruth (left school), Debbie, Bridget, Saskia

Whereas the mathematics teacher decided the class placement of the students in Year 11, in Year 12, the students chose which mathematics course to enrol in. More than half of the students (16 out of 31) were not enrolled in the academic stream of mathematics in Year 12, compared to a much smaller fraction of the students (five out of 31) in Year 11. This is a worrying finding. Like MAT102, students enrolled in MAT202 are restricted in their choices of mathematics courses in Year 13 and at university.

The students' views at the time they enrolled in their mathematics courses in Year 12 were not collected. Examining changes in students' relationship with mathematics over the previous years perhaps can provide some clues to their participation decisions. As discussed in Chapter Two, research in mathematics education has not captured students' perceptions of how aspects of their relationships with mathematics changed over their mathematical journeys. In affective research, although some consideration has been given to how affect relates to students' learning, this process has not been captured over time (Grootenboer et al., 2008), nor has the students' perspective been the dominating view in affective research. In identity research, when a narrative view of identities is taken, it is clear students' identities are constantly changing (Sfard & Prusak, 2005b), but it is unclear if there is any stability in their identities over time.

As described in section 8.3, students accumulated meaning from their mathematical experiences. This meaning altered students' relationships with mathematics, which, over time, formed their mathematical journeys. These were journeys of change and negotiation, shaped by the broader context of students' lives. This section discusses the students' mathematical journeys in terms of the following changes in their relationships with mathematics:

- Many of the students became more negative about school mathematics because they viewed mathematics to be an increasingly boring and difficult subject.
- All of the students experienced tension between their social and academic needs, which peaked when they were aged around 15 years.
- Some of the students found accessing their mathematical knowledge increasingly difficult.
- All of the students experienced changes in their actual and designated identities.
- The students' habits of engagement changed.

It is a common result in mathematics education research that students generally dislike mathematics (e.g., Zan & Di Martino, 2007). Indeed, in this research, the majority of students had neutral or negative macro-feelings about the subject. In reviewing studies into students' attitudes towards mathematics, McLeod (1994) described students' attitudes to mathematics as becoming more negative as pupils move from elementary school to secondary school. The many large-scale questionnaires used in these studies, are very different from the methods used in the current research, yet there are similarities in the findings. The majority of the students became more negative about mathematics as they moved into secondary school. All of the students talked about how the nature of school mathematics had changed. From games

and projects in primary school, mathematics in secondary school became about an increasing number of rules to be remembered and textbook work, with little opportunity to work socially. Many of the students became increasingly frustrated and bored by the repetitive routines of school mathematics. Peter, for example, hated mathematics in secondary school because he was so bored (section 5.2.4). Many of the students found mathematics more difficult in secondary school. Philip, for example (section 7.2), enjoyed mathematics less as it became more complicated and he had to think more. In primary school, mathematics was Ruth's favourite school subject (section 7.4). She had been considered a good mathematician who was chosen for external mathematics activities. In secondary school, she perceived she was now considered by the teachers to be a student who did not achieve success. She hated mathematics in secondary school. As the students' macro-feelings tended to become more negative as they moved through secondary school, the differences between mathematics and other subjects became more pronounced. As described in section 8.2.1, these students made their decision about their participating in mathematics by negotiating between their macro-feelings and how they perceived mathematics would contribute to their future lives.

Hannula (2006) described how students experienced tension when they had conflict between different dominating needs. Indeed, in the current research, all of the students experienced tension between their social and mathematical needs during the research period. This tension generally peaked when the students were near the end of Year 10, or turning 15 years old. In Year 10, Philip assumed that he would fulfil his designated identities if he completed the required work. He wanted to hang out with his mates, and wanted his life to be easy, fun and physical without thought or consequences. Mathematics did not interest him enough to engage him in doing more than the bare minimum required for him to achieve. He experienced tension as he struggled to balance this with his father's expectations of him. Colin (section 7.1) was not immune to the social features of his learning environment in Year 10. He experienced difficulty in achieving his designated identities when there were changes in his own focus, and he became unhappy and defensive for a period of time. Ruth's inability to balance her social needs seemed to begin in Year 9, earlier than the others. Robyn rarely engaged in social talk. Her social needs seemed different from the other students, and seemed to be manifested in her competition with Angela. In general, the students seemed to be able to better balance social needs in Year 11, perhaps because of the parental and teacher expectations relating to Year 11, which was the year the students received NCEA credits towards a qualification. For example, in Year 11, Philip's designated identities associated with his father and his need to do well overtook his social needs and provided him with

motivation to engage. It also may have been that his social needs were better met through increased mathematical discussion.

The students felt that their mathematical knowledge became increasingly unwieldy because of the cumulative nature of mathematics. Every year they learnt new content and new rules and were expected to know these rules in addition to the ones learnt the previous year. As Boaler (2002b) discussed, there is danger in students knowing procedures and not being able to use them in the different situations they encounter. This is precisely what seemed to happen with this class of students. The students' mathematical knowledge became a confused mass of rules. Increasingly, many of the students found accessing these rules difficult. They did not know which rule to use for which situation or, because of negative micro-feelings, which interrupted their thinking, got confused. For example, Mark talked about needing to remember formulae by the bucketful. Saskia talked about not remembering what she is supposed to remember because she was freaking out.

Further extending Sfard and Prusak's (2005a) work, all of the students experienced gaps between their actual and designated identities during the course of their journeys. These gaps were mostly negative and occurred when the students had difficulties in meeting their designated identities, resulting in negative macro-feelings about the subject of mathematics. The students had different success in closing the gaps between their identities. Interestingly, although students' actual identities changed over their journeys, it was the designated identities that experienced the most profound change, as the students' reduced their expectations of mathematical success. For example, Robyn's designated identities were related to achieving in mathematics as well as she did in her other subjects. She had a persistently large gap between her designated and actual identities, and disliked mathematics as a result. Robyn's level of motivation to engage in the mathematics was high because she wanted to do as well in mathematics as she did in her other subjects. Despite working hard, she was unable to close this gap. In Year 11, however, Robyn's designated identities adjusted and she was able to maintain a level of achievement she was comfortable with. Similarly to Robyn, Ruth in Year 9 also experienced a large gap in her designated identities, and was also not able to close the gap with engagement. Ruth closed the gap by drastically reducing her expectations of success, eventually disengaging with mathematics altogether. On the other hand, Philip was able to close the gaps between his identities without lowering his expectations.

That students demonstrate habitual patterns of behaviour and engagement is mentioned in the affective literature by Malmivuori (2006). Much of the previous engagement-related research discussed factors that affect a students' engagement (e.g., Sullivan et al., 2006). There was some evidence that some students' habits of engagement changed over their mathematical journey, but these changes were not marked. Although it is somewhat evident that Ruth's habits of engagement changed from Year 8, and that she briefly worked in Year 11, there was little change in her habits of engagement during the research period. Her routine involvement in the mathematics classroom became limited to socialising from Year 9, and she generally disengaged with mathematics. Colin, who had very effective engagement skills in Year 10, did not demonstrate as much mathematical intimacy in Year 11 and he did not always seek challenges that were enriching. This is perhaps a combination of continued social tensions, and the lack of a competitive environment in Year 11. Furthermore, Colin sometimes struggled to find school mathematics enriching. Even though his designated identities related to performance remained important, his expectations relating to enjoyment and enrichment had diminished. In Year 11, in contrast to others, Philip seemed to make the connection between engagement and success. By engaging more fully in the mathematics, by having more mathematical integrity, and becoming more cooperative, Philip's engagement skills seemed to become more effective. This enabled him to close the gap he had experienced in Year 10 between his actual and designated identities.

One of the main outcomes of this research is that the students' relationships with mathematics were messy. Bloomer and Hodkinson, (2000) in their examination of students' learning careers (section 3.5) found that the learning careers of the people aged between 15 and 19 years were erratic rather than linear or predictable. Rather they are a complex interaction between the school's formal curriculum, social, economic and cultural influences, and everyday learning (Lawy, Bloomer, & Biesta, 2004). Yet, mathematics education literature has not portrayed this messiness. Although students have been portrayed as experiencing tensions because of conflicting needs or goals (e.g., Hannula, 2006), they have been portrayed as 'black' or 'white' in the sense that they have a particular attitude to mathematics or a particular view about the subject (e.g., Zan & Di Martino, 2007). There were a number of contradictions emerging from the students' descriptions of school mathematics. For example, Robyn (section 7.4) worked hard in Year 10 because of her designated identities and because she was sitting next to Angela, even though her stories suggested that she perceived her mathematical ability was fixed. The following year, her macro-feelings about mathematics improved because she was glad to get away from Angela. Even though she linked positive

feelings to better engagement, she had less incentive to compete and her NCEA results were only 'Achieved'. A further contradiction found in this thesis relating to teachers was that the students perceived that their teachers had an accurate perception of their ability, but they also wanted better relationships with their teacher.

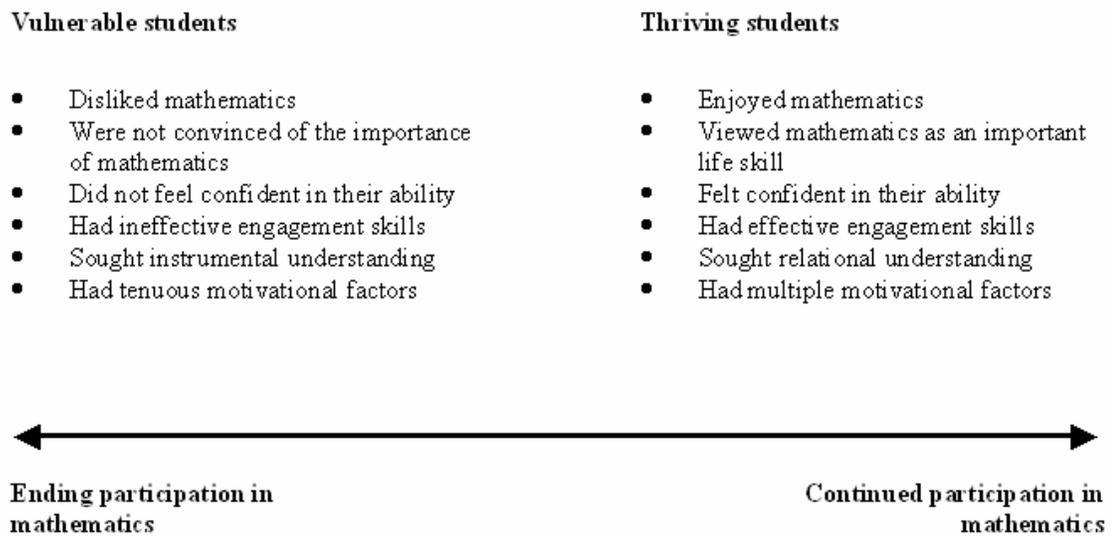
None of the case-study students in Chapter Seven talked about their teachers as a main motivating factor in their mathematics (Figure 7.16). In fact, three of the case study participants perceived their teachers as demotivating. Students essentially held teachers accountable for their feelings about mathematics in their personal journey graphs (section 6.1.1). In future affective research, there is a need to take into consideration that the students' macro-feelings were vulnerable to changes in class and to their mathematics teacher. In Year 11, the students were placed with classmates who had not been in the achievement class. Changing classes at the end of Year 10 allowed Robyn to stop comparing herself with classmates considered to be in the top group. The positive change in Robyn's macro-feelings in Year 11, without Angela's presence in class, was marked. Other Year 10 students also enjoyed the change of class. In Year 11, they received credits throughout the year towards an NCEA qualification and this may have led them instead to compare themselves with a broader set of students, rather than others in the achievement class. On the other hand, students' often associated their mathematics teacher with the routines, the difficulty of mathematics, and their overall dislike of the subject. For example, Joanna disliked mathematics in Year 11, and attributed this to the change in teacher.

A further example of messiness is the link between students' views of their intelligence and their engagement. Dweck (1999) linked students' engagement in mathematics with their beliefs about mathematical intelligence, and indeed, there was some evidence that students linked their knowing of mathematics with their perceptions of their mathematical ability or intelligence. Colin, for example, linked "knowing" with his mathematical intelligence. He viewed intelligence as his present level of knowledge, which accumulated as he engaged in and learnt more mathematics. In this sense he had an incremental view of his intelligence. Although Colin certainly linked his knowing with engagement, how others connected engagement and intelligence is less clear. Many of the other students had an entity view of their intelligence. In other words, they believed "how good" they were at mathematics was fixed rather being a function of their present skills and knowledge. According to Dweck (1999), students with an entity view of intelligence thought there was no point in trying hard because it would not improve their ability. Differently to Dweck's (1999) research, the

majority of students associated learning with “doing mathematics”. They saw engagement as a necessary prerequisite for learning. Their view of intelligence did not necessarily account for their habits of engagement. For example, Robyn, viewed her mathematical ability to be fixed, but yet constantly applied herself in mathematics.

The implication of this messiness is that no direct connection can be made between students’ relationships with mathematics and their decision to participate in mathematics. Every student is unique and it is difficult to make predictions about their continued participation in the subject of mathematics. Over students’ mathematical journeys, elements of their relationship had different significance to the students depending on their interpretation of their learning experience. What can be said is that, for the majority of the students, their participation in mathematics was vulnerable.

In understanding students’ relationships with mathematics and the changes they experienced in these relationships during their mathematical journeys, the students could be identified as ‘vulnerable’ or ‘thriving’ in mathematics. Sullivan et al. (2006) described the engagement of students who were unconvinced of the importance of mathematics as “vulnerable” (p. 90). This notion is extended in this research to discuss the vulnerability of students to non-participation in mathematics – their choosing not to continue to enrol in the subject. Students who were more *vulnerable* were those that were not thriving in mathematics, and who may potentially choose not to continue with the subject. Students who *thrived* were those who were likely to continue to participate in mathematics. Figure 8.2 shows the characteristics of vulnerable and thriving students. These are not intended to objectify students as vulnerable or thriving. The students’ relationships with mathematics were constantly changing throughout their journey (section 8.4), and these characteristics are aspects of these relationships. Rather, the students sat on a continuum between thriving and vulnerability and moved back and forth along that continuum throughout their journey.



**FIGURE 8.2 Continuum of participation**

Even though many in this group of students were successful in meeting the expectations of their year level, they could not be considered to be thriving mathematically. All of the students had some degree of vulnerability. Students with increasingly negative macro-feelings about mathematics were more inclined to drop out. They preferred to do other subjects that they enjoyed more. These vulnerable students often had ambiguous views of the importance of mathematics and rarely made a connection with mathematics as a skill needed throughout their lives, although they knew it was necessary for specific careers. For example, Saskia, Debbie, Peter, and Frank did not see mathematics as important in their future and chose not to continue in mathematics. Bridget, who also chose not to continue in mathematics, was one of the students who increasingly hated the subject compared to her other subjects (section 6.1.1), and wrote in Year 10 that she did not intend to take it to a senior level in school (section 6.1). Students who were not confident in their ability to improve their achievement in mathematics to meet what was expected of them were vulnerable. Unable to remain confident when they experienced a problem, they perceived that failure to solve a mathematical problem was because their mathematical ability was lacking, rather than viewing difficulty as a signal to persevere.

If vulnerable students fell behind in mathematics because of increased social needs, or problems in their family, the cumulative nature of mathematics meant mathematics was a particularly difficult subject to catch up on. Many of the students were not thriving in mathematics because their engagement skills were not effective (section 8.2.5), particularly

when they needed to catch up on missed work, or close gaps between their actual and designated identities.

Other students' engagement skills were not as effective as Colin's. They described disengagement or superficial engagement in the mathematics. When they experienced difficulty in a mathematical task, they were not resilient to micro-feelings of confusion and were more likely to disengage from the task when they experienced these feelings. Some of these students had inadequate concentration, which also affected their perseverance. For example, Moira described herself as distracted easily. Susan suggested the use of a cattle prod to help her concentrate (section 5.1). When Bridget was absent for a period of time, she found it very difficult to catch up on missed understanding because of her poor engagement skills.

The case study students who did not have many motivational factors were also vulnerable to non-participation. As seen in Table 7.16 (section 7.5), Ruth had only one, fairly tenuous, motivating factor in mathematics. The routines of school mathematics encourage students to seek instrumental understanding, and they could potentially achieve success in school mathematics with this understanding. The students with an instrumental understanding of mathematics, often became increasingly confused by the mass of rules that needed to be remembered and for many of the students, this added to their vulnerability.

A few students seemed to thrive in mathematics more than the others. They enjoyed the subject, and were confident in their ability. They had highly developed engagement skills. Colin was the student who seemed to thrive the most in school mathematics. Colin (section 7.1) was a student with highly effective engagement skills. He persevered in a task even when it initially looked hard or he reached a hurdle or became confused. He anticipated that he would have difficulties in a mathematical task and experience micro-feelings such as confusion, slight anxiety, as well as curiosity. He was not just resilient to these micro-feelings, he was aware of and utilised these feelings. They were signals to change or persevere with his current strategy. Colin knew if there were difficult problems he would "learn how they work eventually". Experiencing difficulty in the mathematics was not a challenge to his ability, because he did not view ability as being fixed. He saw each mathematical task as an opportunity for enrichment because he had an emotional intimacy with mathematics. Colin wanted to be able to do a problem, but he was also curious and wanted to explore and understand why it was done that way. He demonstrated mathematical integrity. He was better able to construct the procedures when he needed them rather than needing to know them "off

by heart". He was also skilled at working both independently and cooperatively, often discussing the mathematics with the teacher and his classmates. Colin actively fostered his engagement skills by reflecting on them. Despite experiencing some tension in Year 10, Colin continued to engage in mathematics to a high level and perform well. His strong need for enrichment and achievement and his very effective engagement skills managed to support him when he experienced negative gaps between his identities. There is some evidence that Colin sought relational understanding, and he was not so reliant on his memory of rules to complete mathematical tasks. Despite some evidence in Year 11, that he was no longer as intimate with school mathematics as he had been, and with his focus in Year 11 on other subjects, he may still continue to participate in the field, in some form, throughout his life.

The students' relationships with mathematics changed over their mathematical journeys. These changes were generally subtle, but over time, they were important because the student could change from a thriving student to one who is more vulnerable to disengaging from the subject of mathematics. Many of the students in this research were vulnerable to begin with, and became more vulnerable over time, resulting in more than half of them choosing not to pursue mathematics in the academic stream.

These findings are unique because they describe, in detail, the characteristics of vulnerable mathematics students and the implications of that vulnerability. Importantly, unlike other research talk about anxious students (e.g., Tobias, 1990), or students having a certain attitude (e.g., Dutton & Blum, 1968) vulnerability is not a trait. Rather, students' relationships are dynamic, and as they experience mathematics, they are constantly moving towards or away from vulnerability.

## **8.5 Implications for mathematics teaching**

The word and actions of the mathematics teachers involved in the research were found to have considerable influence on the students' relationships with mathematics. Through the teachers' choice of tasks, the routines of the mathematics class, where they allowed the students to sit, and through their interactions with the students, the teachers helped to construct the social norms of the mathematics classroom, influenced the students' views about mathematics, and contributed to the students' mathematical knowledge.

The teacher has been recognised as the most important influence on students' achievement (Hattie, 2003). Averill (2009) in her analysis of teacher-student relationships in a New Zealand mathematics classroom said that there was a need to explore how students' impressions of their teacher's knowledge of their mathematical capabilities are created. In the current research, depending on the student's relationship with the teacher and the significance of the evidence to the student, the teachers' view of the students' ability potentially contributed to students' actual identities. Students' formed perceptions of their teachers' views of their ability through their interactions with the teachers and their teachers' recognition and reporting of their own and others' progress and performances. The teachers communicated with the students through their classroom interactions, their reporting, the choosing of students for extension opportunities, and the rewarding of prizes. The teachers' manner when the students sought help and their reception and seeking of student comment in class discussion also contributed to this perception. The mathematics teachers potentially provided actual identities for the students about their ability to do the mathematics. Furthermore, the students described their teachers as a main factor in their macro-feelings about mathematics, and the way the teachers supported the students when they experienced difficulty reinforced the students' habits of engagement. Therefore, the teachers' words and actions influenced where the students were positioned on the continuum of participation during the research (figure 8.2).

There are a number of implications for teaching practice that can be drawn from the research. Although the conclusions of this research pertain to a small group of students in New Zealand, teachers can evaluate these implications according to their own contexts.

From the research emerged the understanding that the students had relationships with mathematics, made up of several elements, which affected their engagement and changed over time to form their mathematical journeys. Furthermore, understanding emerged about how students' decisions to continue to participate in mathematics were affected by the degree to which they could be considered to be vulnerable or thriving. Being aware of these understandings, and being aware of the influence the mathematics teachers had on the students' relationships with mathematics, could help mathematics teachers in the future to get to know their students better and reflect on their own classroom practices.

In this research, the students as a group said that they wanted their teachers to get to know them better in terms of their learning, feelings and expectations related to mathematics, and as

a person with a life outside the classroom. They wanted their teacher to understand their feelings about mathematics, the triggers that upset them or “set them off”. They wanted their teachers to understand how they individually interpreted their progress and results. The students wanted the teacher to interact with them more on a one-to-one basis. They also wanted their teachers to understand that their feelings about mathematics changed during their journey, and they wanted their teacher to keep up to date with the changes (section 6.1.1). By actively getting to know the students in their class, teachers can better meet these needs. Furthermore, by getting to know the students better in terms of aspects of their relationships with mathematics over time – their feelings about mathematics, their views of the subject, their level of confidence, expectations, and motivational factors – the teacher would be better informed to help individual students to thrive mathematically. This research provides an example of how teachers can get to know students better through the use of metaphor, drawings of mathematicians, autobiography, and personal journey graphs.

The students in this research needed and wanted to have more social elements in their mathematics lessons, use each other as resources and emotional support, *and* socialise. Indeed, the social world of the students emerged as an important factor embedded within their mathematical learning. Social elements enhanced the students’ engagement, enjoyment and understanding of the mathematics (section 6.3). Yet, in this research, it was found that socialising was considered by the teachers (and the students’ parents) to be detrimental to the students’ mathematical learning (section 6.3). The routines of school mathematics, with the domination of individual textbook work, reinforced the students’ perception that mathematics was intended to be done in isolation. Indeed, there were few opportunities for students to work with classmates. This has a number of implications for teaching. The majority of the students in this research did not enjoy mathematics. If the importance of the students’ social world and their social needs can be accepted and harnessed in the mathematics classrooms, if social elements are better incorporated into mathematics lessons to account for these strong social needs and the social nature of learning, then students are more likely to enjoy mathematics more. Further research is needed into how this could be done. Explicitly encouraging discussion, and teaching help-seeking and giving skills may be ways of doing this. Encouraging students to learn cooperatively both formally and informally would also encourage social aspects of the lesson. This research found that which classmates a student sat near also made a difference to the social aspects of the lesson, and this is summarised now.

In analysing the themes of the context of the moment, students' seating arrangements emerged as an important part of the context for the students' doing of mathematics. This is a new finding in affective research in mathematics education. As described in section 6.3, because of the multitude of comparisons the students made with each other, the students were particularly aware of and interacted with those seated near to them. To enable them to learn mathematics socially, all of the students wanted their teacher to help them control their social needs, and to establish seating plans in the mathematics classroom. The students described more positive feelings and better engagement when two conditions operated. Firstly, a seating arrangement was successful when the student felt comfortable with the others they were sitting near. Students were most comfortable when they liked the student they were sitting with and when the nearby students were at a similar level mathematically. Knowing and liking each other was important to this class of adolescents. The comparisons made by students close by who were not the same level as each other mathematically often resulted in negative feelings. Students who were comfortable with the students they were seated near, particularly if they were at the same level mathematically, were more cooperative in their mathematical learning, discussed the mathematics more with each other, and were less reliant on their teacher for help. Secondly, a seating arrangement was successful when other students' behaviour did not negatively affect them. Students often felt powerless to control others' behaviour and could only work if their classmates' behaviour allowed it. Compared to fulfilling their strong social needs, doing mathematics was not a priority for some of the adolescent students (section 5.1). Establishing successful seating plans can help teachers to harness these adolescent social needs.

In this research, the students' views about mathematics were linked with their macro-feelings and other aspects of their relationship with mathematics. The students' views that emerged from the analysis were related to their perceptions of mathematics as boring and difficult, and their perception of the subject's nature and importance. The students of this research experienced persistent boredom. To help counteract the boredom, the students wanted variety in their lessons; variety that they did not experience in mathematics. The students in this research generally found mathematics to be difficult because of the pace of the lessons, and the cumulative nature of the content. Mathematics teachers could reflect on the structure of their lessons, the tasks they assign, and the ways content is introduced. Reflection is also needed on how other factors contribute to the unique pace, such as the cumulative nature of mathematics the students described and the instrumental understanding they sought. Despite a mathematics curriculum that advocates mathematics lessons that include variety, the use of

manipulatives, and the opportunity for students to construct their own mathematical understandings (e.g., Ministry of Education, 1992, 2007), this was not happening in these mathematics classroom – similar to many mathematics classrooms around the world. This opens up a wider issue on the impact of research on classroom practices and the sorts of constraints that restrict changes happening in classrooms, not considered in this thesis. Further research needs to be done into both how this can be changed within a classroom, and how it can be changed in terms of mathematics curriculum.

The students of this research had ambiguous views about the importance of mathematics. They were aware their families considered mathematics to be important, but experienced tension as they negotiated between their parents' views, their macro-feelings about the subject, and their experiences in the classroom. The students also distanced themselves from mathematics in their future. As a result of their experiences in the classroom, they seemed unaware of the messy, collaborative, and at times confusing work that mathematicians did. If mathematics was emphasised as an important subject for life-long learning, rather than a subject that will emerge as useful at some later stage during the student's career, then students will be less ambiguous about the importance of mathematics and may be more likely to continue their participation in mathematics. There is a need to explore how mathematics teachers can better connect school mathematics with the discipline of mathematics, mathematicians, and how mathematics functions in everyday life.

In this research, the definition of students' relationships with mathematics, the definition of students' engagement skills, and the characteristics of vulnerable and thriving students provided a structure that allowed individual students' mathematical journeys to be assessed, monitored and compared. This research therefore provides an example of how students can be monitored during their mathematical journeys.

Furthermore, this research found that the different aspects of the students' relationships with mathematics all affected the students' learning in mathematics. Students' feelings about mathematics, the ways they engaged in the mathematics, their perceptions of their ability and expectations, their views of the subject, their ideas about knowledge are all integral to the learning process. These aspects need to be accounted for in research and in teaching practice. Furthermore, by communicating some aspects of these elements to the students and parents, teachers can help more students to thrive in their classrooms. For example, teachers could be

explicit about effective engagement skills, such as helping students recognise and act on feelings of confusion and worry when working on mathematical tasks.

## 8.6 Further research

This investigation was centred on students' relationships with mathematics, and consequently adopted a very broad and complex understanding of these relationships. There are a number of ways this research could be developed further to understand some of the issues in more detail. Some of these relating to mathematics teachers have been discussed in the previous sections. Other research needed is discussed in this section.

Enlarging the longitudinal aspect of the study would capture students' mathematical journeys further. The students in this research described how they found the transition from primary school to secondary school particularly difficult and it would be interesting to fully capture this transition. Furthermore, in this research, six students did not continue to participate in mathematics (see table 8.1) and it would be interesting to track how this affected their choices when they left school. It would have also been useful to extend the study until all the students had left school and their decisions after this time so that more of a pattern of non-participation in mathematics could emerge. Longitudinal studies are expensive and rarely practical, but valuable data about students' decisions to participate would help to build the concept of a sustainable thriving mathematics student.

The parents' voices which emerged in the students' views and feelings about the mathematics were an interesting aspect. Parents were found to make important contributions to the students' relationship with mathematics. Parents influenced students' views of mathematics and their macro-feelings about the subject and the students' teachers. For some students, they were significant narrators of their designated identities and were therefore important motivators. There is already some research into the area of parental influence on students' mathematical learning (e.g., Cao et al., 2006; Pritchard, 2004). More specifically, in order to establish how communication between the school and parents can enhance adolescents' mathematical journeys, the voices of parents and their effect on the students' identities need to be further examined.

The students generally sought instrumental understanding of mathematics because the routines of school mathematics emphasised the learning of specific procedures to solve short-

answer textbook problems. This created issues with the students because they viewed mathematics as an accumulating mass of procedures that needed to be learnt “off by heart”. There is some evidence in this research that a thriving mathematics student is one that seeks relational understanding. Learning mathematics by constructing their own knowledge is certainly one way for students to achieve this. However, it takes time to facilitate the construction of a student’s understanding of a concept rather than simply showing them an end product and teaching them the algorithmic steps to get there. Radford (2008) cautions that teacher’s need to guide students to achieve a balance between constructing their own knowledge and highlighting the kinds of reasoning and methods valued by mathematicians. In order to provide specific recommendations that enable teachers to achieve this balance, more research is needed.

The students perceived mathematics to be a unique subject. Although this has been done already to an extent (e.g., Shannon, 2004), there is a need to more thoroughly compare the elements of students’ relationships with mathematics with students’ relationships with their other school subjects at both a subject level and a task-level. A comparison of the different teaching approaches used in other subjects would also be valuable.

## 8.7 Final remarks

The students’ mathematical journeys in this research provided rich data that helped to understand each student’s ability to thrive mathematically and their vulnerability to negative feelings, disengagement, and non-participation. Students’ participation in mathematics is vital in ensuring individuals can develop the mathematical concepts and skills to consider mathematics to be a valuable part of their lives. In examining students’ mathematical journeys, this research had elaborated on the connection between students’ participation in mathematics and the field of affective research in mathematics education.

The genealogy of research into affect was mapped into three phases, which was a valuable way of organising the large body of literature. I was able to grasp the emerging understanding of the role that affect plays in students’ learning. For each phase, I have provided a summary of the research findings and the methodologies used, a critique of the research, and a number of unresolved issues noted (Table 2.1). This provides a useful summary for other researchers seeking to understand aspects of the literature associated with the affective domain.

More importantly, the unresolved issues identified in the three phases have been addressed in this research. Thus, this research potentially heralds the start of a fourth phase of affective research into mathematics education. Future research in this area will need to consider how to effectively take into account the features of this emerging phase. These features as outlined in this thesis are listed below.

- Affect is one important aspect of students' relationships with mathematics, and affective research needs to explore these relationships.
- There are many studies that deal with students' more intense affective responses. However, this research has found that less intense affective responses can accumulate over time, contribute to students' negative macro-feelings about mathematics and signal a persistent gap between their actual and designated identities, potentially leading a student choosing not to participate in mathematics. Future research into mathematical affect needs to identify both strong and less intense emotions that contribute to students' responses to their mathematics learning.
- Research into affect should be centred on school students and their perspectives of learning mathematics in order to understand the relationship between students' affective responses and their learning. Previously, students' perspectives on learning have been captured through short response surveys. This has been insufficient in understanding the complexity that produces students' affective responses to mathematics education. In this current research, it was the meanings students took from a situation or experience that were important rather than the researcher's interpretation of the situation.
- To capture the association between students' relationships with mathematics and students' learning, affective research needs to take place in mathematics classrooms. This is because students construct meaning through participation in the practices of the mathematics classroom, and their mathematical journeys are situated in the classroom and in the wider context of the school and their family life. Within their journeys, students' affective responses and identities happen within the context of the classroom and are not detachable from the specific individual and the current situation.
- Affect cannot be separated from students' whole lives. Students' social needs, relationship break-ups and distress over family issues have an impact on their mathematical learning in the same way as students' reluctance to do repetitive exercises from the textbook.
- Affective research must consider the notion of students' identities. Sfard and Prusak (2005a, 2005b) used ideas about actual and designated identities to investigate the

cultural differences between two ethnically different groups of students (section 3.4).

The current research investigating students' identities in a New Zealand classroom provides another example of how Sfard and Prusak's (2005a, 2005b) ideas can be used. This research has extended Sfard and Prusak's research in a number of other ways. The influence of parents, classmates, and teachers has been further understood. Sfard and Prusak (2005a, 2005b) suggested that students with persistent gaps between their actual and designated identities would experience a sense of unhappiness. In this research, these gaps were examined more closely in relation to students' affective responses and other elements of their relationship with mathematics. Furthermore, these gaps and changes in students' identities were examined over time. In affective research, students' affective responses need to be analysed in relation to the gap between their actual and designated identities. Sfard and Prusak (2005a, 2005b) argued these gaps result in learning. Although there was evidence that these gaps were a factor in students' motivation to engage, they also resulted in adjustments to designated identities. Future research around affect and mathematics education needs to take account of the different possibilities that arise in the gap between actual and designated identities.

- To enable affective researchers to be able to have a full picture of how affect influences students' desire to engage with mathematics, research design needs to have length, breadth, and depth. To capture students' perspectives on their relationship with mathematics over time, I developed the methodology of this research to have the three dimensions of length, breadth, and depth. The study was done over two years, multiple data sources were used with a variety of tools, and the analysis was inductive (section 4.1). If only one data tool had been used, the richness and complexity of the students' mathematical journeys would not have been captured. For example, during Philip's Year 10 interview, his responses to many questions were very brief, whereas classroom observation, teacher reports, his group interview, and his written responses sometimes revealed a different perspective on his engagement in mathematics. Philip's stories needed to be captured over time. If Philip had only been glimpsed in the first half of Year 10, there would have been insufficient understanding of the effect of the shifting gap between his actual and designated identities. In the first half of Year 10 Philip wanted to be an All Black rugby player and the subject of mathematics was unimportant. It was "his way" to be the class clown. Without the following year's data, there would have been no understanding of the effect the sitting of the mathematics exam had on him. Philip's engagement changed over the years from above average to class clown to a steady worker. Affective research needs to understand students' relationships with

mathematics over time, rather than gauging students' affect at one moment in their mathematical learning journey.

As said at the beginning, this thesis is about a group of students who are on journeys through adolescence. Their mathematical journeys have enabled me to glimpse into their lives and begin to understand their complex and dynamic relationships with mathematics. These glimpses have provided a detailed account of the sameness and variability, as well as the messiness and contradictions of these relationships. For these students, learning mathematics was an emotional practice, and was both social and individual. The students in this research were all adolescents; they came from similar sociocultural backgrounds, and participated in the same classroom community. Despite these similarities, because they each had a unique relationship with mathematics, each student interpreted the meanings of their experiences, engaged in mathematics in different ways, and had unique learning experiences and outcomes.

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# APPENDIX A: Observation Template

Date:

Teacher:

Absent:

Lesson Plan:

Seating Plan:

<input type="text"/>					
<input type="text"/>					
<input type="text"/>					
<input type="text"/>					
<input type="text"/>					
				<input type="text"/>	<input type="text"/>
					<input type="text"/>

General Comments:

Research tools and comments:

STUDENT	OBSERVATION	INITIAL INTERPRETATION
Frank		
Ann		
Katrina		
Alasdair		
Dawn		
Ruth		
Peter		
Debbie		
Moira		
Bridget		
Susan		
Nicola		
Sean		
Mark		
Corrina		
Philip		
Cheryl		
Jennifer		

APPENDIX

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Tia		
Amanda		
Jason		
Colin		
Robyn		
Angela		
Ben		
Connor		
Lola		
Paul		
Joanna		
Jill		

## **APPENDIX B: Mathematics**

### **Autobiography**

The students were asked to complete sections of a mathematics autobiography at different times during the research period. There were four sections in their mathematics autobiography.

1. Questionnaire (see 4.4.4)
2. Drawing of a mathematician (see 4.4.6)
3. Metaphor work (see 4.4.5)
4. Personal journey graph (see 4.4.7)

The questionnaire and the metaphor work are duplicated in this appendix.

## Student Questionnaire

Your answers to the following questions will help me to understand how you feel about doing maths. Please answer them as fully as you can. Use the back of the sheet if you need some more room.

Name \_\_\_\_\_

1. In Year 10 you have to take maths as a subject. If you had a choice, would you take it?

Yes \_\_\_ No \_\_\_

Why?

\_\_\_\_\_

\_\_\_\_\_

2. Please fill in the following and place a cross where you think you are on the lines.

List your subjects	How do you feel about your academic achievement in this subject?	Do you worry about this subject?
English	← Disappointed   Great →	← No   Yes →
Maths	← Disappointed   Great →	← No   Yes →
Social Studies	← Disappointed   Great →	← No   Yes →
Science	← Disappointed   Great →	← No   Yes →
	← Disappointed   Great →	← No   Yes →
	← Disappointed   Great →	← No   Yes →
	← Disappointed   Great →	← No   Yes →

3. Do you think you are achieving the marks you are capable of?

Please fill in your Subject	Yes/No
English	
Maths	
Social Studies	
Science	

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If your answer is no to any of the above, explain specifically the reasons why you think are not achieving your potential.

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4. How often do you understand what you are taught in maths class?

Always \_\_\_ Usually \_\_\_ Sometimes \_\_\_ Hardly ever \_\_\_ Never \_\_\_

What topic/s in maths do you find the most difficult and why?

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5. Is there someone at home that can help you with your maths?

Friends \_\_\_\_\_  
Parent/Care Giver \_\_\_\_\_  
Brother/Sister \_\_\_\_\_  
Tutor \_\_\_\_\_  
Other \_\_\_\_\_  
\_\_\_\_\_

6. Do you think that the class that you were put into had an effect on how you feel about maths?

No \_\_\_\_\_  
Yes \_\_\_\_\_

Comment on what sort of effect it had.

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7. Tell me as much as you can about how you like to learn in maths class.

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8. What things does your teacher do now to help you feel better about maths?

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9. What *could* the teacher do to improve how you feel about maths?

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10. Is there anything else you would like me to know about you?

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**Feelings about Mathematics** – For each item, please tick which box best fits you.

	Not nervous	A little bit nervous	Very nervous	Very Very Nervous
Getting a new textbook				
Reading and interpreting graphs or charts				
Listening to another student explain a maths problem				
Watching a teacher work a maths problem out on the whiteboard				
Walking into a maths class				
Looking through the pages of a textbook				
Starting a new topic				
Thinking about maths outside class				
Begin working on a homework assignment				
Working on a problem such as: "If I spend \$3.85, how much change will I get from \$20?"				
Reading a formula in science				
Listening to the teacher in maths class				
Using the functions buttons on the calculator				
Being asked to answer a maths problem in front of the class				
Being given a homework assignment of many difficult problems due the next day.				
Getting ready to study for a maths test				
Taking a quiz in a maths class				
Thinking about a maths test the day before the test				
Doing a maths test				
Waiting to get a maths test returned in which you expect to do well				
Being given a maths test you were not told about				

APPENDIX

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I enjoy studying maths at school					
Maths is the subject I like least at school					
Maths is a useful and practical subject					
Maths is interesting					
Most of the maths I have learnt has been of little use					
People would think I was a nerd if I did really well in maths					
Generally I have felt okay about attempting maths					
I'll need maths for my future career					
I'd be happy to get good marks in maths					
I don't think I could do advanced mathematics when the time comes					
It wouldn't bother me at all to take more maths classes					
Even though I work hard, maths seems unusually hard to me					
I will use maths in many ways as an adult					
People would like me less if I was a really good maths student					
My mind goes blank and I can't think clearly when working in maths					
Knowing maths will help me earn a living.					
If I got the highest mark in maths, I'd prefer no one knew					
I think I could handle more difficult maths					
Winning a prize in maths would make me uncomfortable					
I'm not the type to do well in maths					
Maths doesn't scare me at all					

## Metaphor Prompts

1. Pretend that you have to describe mathematics to someone. List all the words or phrases you can think of that you could use.
2. Imagine doing or using mathematics either in or out of school. What does doing or using mathematics feel like? List all of the words or phrases you would use to describe what doing or using mathematics feels like.
3. Think about the things that mathematics is like. List all of the things or objects that you think mathematics is like. List each object you choose on a separate line on your paper.  
Prompts: If mathematics were a building, what would it look like? If mathematics were a vegetable, which vegetable would it be?
4. Write a paragraph beginning “For me mathematics is most like a(n) \_\_\_\_\_”. In the paragraph, discuss the ways in which your object and maths are similar.



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# APPENDIX C: End of Year 10 Student Questionnaire

1. Name \_\_\_\_\_

2. What were your results in the maths exam?

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3. How did you do in your other exams?

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4. In terms of your maths exam, were the results better/worse or the same as what you were expecting? Were there any surprises?

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5. Did you study for the maths exam outside of class?

Yes \_\_\_ No \_\_\_

If yes:

How much (hours/minutes)? \_\_\_\_\_

How did you study? Be specific

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If no:

Why not?

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6. Are you good at maths? Yes \_\_\_\_ No \_\_\_\_ Other \_\_\_\_\_

Comment:

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1 (near the bottom)      2      3 (average)      4      5 (in the very top group)

Are you good at maths compared to others in this class?					
Are you good at maths compared to all Year 10 students?					

7. What does boring mean?

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8. I feel negative emotions in maths when:

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9. I feel positive emotions in maths when:

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10. Do you like seating plans? \_\_\_\_\_

11. How do you think seating plans affect your learning?

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12. Do you ever feel anxious in maths?      Yes \_\_\_      No \_\_\_

If yes, when do you feel anxious?

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13. What makes maths different to other subjects? Are these differences negative or positive?  
What effect does this have on your maths learning?

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14. Any other comments to make?

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## APPENDIX D: Parent questionnaire

Naomi Ingram  
Department of Mathematics and Statistics  
University of Otago

Dear Parents,

I have been enjoying spending time in the classroom with the students of 10B. I have observed them working through the topics of probability, geometry, and measurement, doing tests and activities, working in their exercise books, asking questions, going through homework, and talking to the teachers and each other.

I am very interested in how you feel about maths and in hearing about some of your experiences with the subject. This will help me to understand your child a little better. Please fill out the attached questionnaire as fully as possible and send it back to me in the envelope provided. I appreciate the survey is a long one, but I am very interested in your responses. Be assured that your privacy will be protected and no names will be used. Your responses will not be discussed with your child or their teacher.

It would be great if these questionnaires could be sent back by the end of August so I can begin analysis. Please do not hesitate to contact me if you have any queries,

Thank you so much,

Yours sincerely,

Naomi Ingram



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Comment

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5. To what level do you think it should be compulsory for your child to take maths?

\_\_\_\_\_ Use any of: Age/Form/Standard/Year/Level/Grade

Why?

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6. Describe any current concerns you have with your child's maths (if any).

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## PART TWO: YOU

1. Name \_\_\_\_\_

2. What do you remember about learning maths at primary school?

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3. What do you remember about learning maths at secondary school?

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4. How did you feel about maths at school?

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5. If you have a significant memory of maths at school that shaped how you feel about maths today, describe this memory.

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6. What topic/s in maths did you find the most difficult at school?

\_\_\_\_\_

7. What topic in maths did you like the most? \_\_\_\_\_

Why?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

8. What topic in maths did you like the least? \_\_\_\_\_

Why?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

9. Please tick the highest Maths Qualification you have achieved

- No Qualification \_\_\_\_\_
- School Certificate \_\_\_\_\_
- Sixth Form Certificate \_\_\_\_\_
- University Entrance \_\_\_\_\_
- Bursary \_\_\_\_\_
- NCEA (please specify level) \_\_\_\_\_
- Tertiary Course/s (please specify highest) \_\_\_\_\_
- Other (please specify) \_\_\_\_\_

10. What do you do and how do you feel now when you come across maths in daily life? This could be, for example, in your place of work, filling out tax returns, working out discounts, thinking about mortgages, understanding political polls, or interpreting graphs.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

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11. For the following questions, please tick one of the boxes.

	Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree
Maths is a useful and practical subject					
Most of the maths I learnt at school has been little use					

Any other comments?

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