The Effects of Primary Students' Mathematics Self-efficacy and Beliefs about Intelligence on Their Mathematics Achievement: A Mixed-methods Intervention Study

by

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Abstract

A mixed-methods quasi-experimental methodology was used to identify relationships between primary-school students' beliefs about intelligence, mathematics self-efficacy, and achievement, by investigating the effects of two interventions. One intervention aimed to strengthen students' mathematics self-efficacy, and the other aimed to develop in students' an incremental theory-of-intelligence – a belief that intelligence is malleable. In one group, teachers implemented both interventions with their students; in a second group, teachers implemented only the mathematics self-efficacy intervention, and the third (control) group were involved in no intervention. Year 4 and 5 students (n = 152) completed a questionnaire on three occasions, at intervals of about 7 months, to measure their theory-of-intelligence and their mathematics self-efficacy. Students made self-efficacy judgments in relation to specific number problems, which they were subsequently required to solve for the mathematics achievement measure. Both achievement and self-efficacy were then calibrated for each participant using the difficulty parameters for test items. Teachers completed questionnaires about their theory-of-intelligence and self-efficacy for teaching mathematics. Sub-samples of teachers and students were interviewed to develop a deeper understanding of what their questionnaire responses signified.

The combined interventions had no significant effect on students' beliefs about the malleability of intelligence, mathematics self-efficacy, or achievement. In contrast, positive effects on students' mathematics self-efficacy and achievement were evident for students who experienced only the self-efficacy intervention. Teachers in this intervention group reported increased use of three strategies aimed at building students' mathematics self-efficacy: providing students with strategies for coping when learning became difficult; increasing their use of descriptive teacher-student feedback; and increasing their use of similar peers as models. For the self-efficacy intervention group, increases in students' mathematics achievement and self-efficacy appeared to be reciprocally related.

The combined quantitative and qualitative evidence from the study showed that the complexity of some students' and teachers' beliefs about increasing intelligence was not reflected in their total scores on the theory-of-intelligence items used widely in earlier studies. In interviews, all students and most teachers described intelligence as malleable to varying degrees, which did not support previous dichotomous interpretations of theory-of-intelligence data. From students'

definitions of intelligence, two related dimensions were established, one a fairly stable capacity for acquiring knowledge and skill in a given domain, and the second, the more malleable rate at which such knowledge and skill can be acquired. A variety of beliefs were expressed by students about which of these dimensions intelligence includes, and about how malleable the dimensions are. The findings raise questions about the value of advocating an incremental theory-of-intelligence for all students, regardless of their ability and how they conceptualise intelligence.

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Working on a PhD is a challenge – a Mount Everest of academic study, I've been told. Most importantly, I thank Peter for directing my attention to the mountain in the first place, and for his unwavering support during the climb. My mountaineering experience was eased considerably by the company of my precious family, their confidence in me propelling me onwards and upwards.

Although the destination in such ventures is the goal for many, for me the process of ascending was the prize. My trusty sherpas, Associate Professor Joanna Higgins and Dr Michael Johnston, accompanied me all the way up the mountain, and helped me to read the signs of – and avoid – blizzards, crevices, and avalanches. Fellow climbers from various parts of the globe were also influential in encouraging my progress during the ascent. At a hut where many novice climbers congregated, I made a number of friends, some of whom completed their ascent ahead of me and generously shared their experiences to help me avoid the rocky outcrops they had encountered on the mountain. Much of their advice had in turn come from their own sherpas. Another friendly climber I met on the foothills, as we both engaged in learning about statistics in preparation to take on our separate mountains. I still have much to learn about statistics, and one of my sherpas, Michael, undertook the item response modelling reported here, on my behalf.

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CHAPTER 1
Introduction

Background

The present study was undertaken to investigate the relationships between primary students' achievement in mathematics and two aspects of their beliefs about learning – their *mathematics self-efficacy*, and their beliefs about the malleability of intelligence, referred to here as their *theory-of-intelligence*. The former is specific to mathematics and, in fact, to particular mathematics problems, and the latter is a global belief that some researchers (for example, Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2000) have suggested influences a student's learning.

The aim of the present research was primarily to test the effects of two interventions, by using a combination of quantitative and qualitative research strategies. Priority was given to the quantitative data, with qualitative data intended to assist interpretation of the quantitative data. Even though the international research literature has firmly established the correlation of self-efficacy with student achievement (for example, Chen, 2003; Pajares & Miller, 1994; Schunk & Hanson, 1985), only one study (Siegle & McCoach, 2007) has included an in-class intervention to investigate ways in which primary students' mathematics self-efficacy can be influenced by their teachers in order to improve student achievement in mathematics. No classroom-based intervention studies were found that aimed to strengthen primary students' beliefs in the malleability of intelligence. Furthermore, many studies related to mathematics self-efficacy and theory-of-intelligence (for example, Ahmavaara & Houston, 2007; Law, 2009; Pajares & Graham, 1999; Schunk & Hanson, 1985) report only data gathered from Likert-type scales on questionnaires, whereas the present study used a mixed-methods design to give the investigation greater depth. Finally, findings from cross-sectional studies have been used to try to build a picture of how students' beliefs vary from year to year. In the present study, data were collected from the same students over a 14-month period to identify changes in their beliefs.

Definition of key terms

One of the issues that will be highlighted in the review of relevant research literature is the problems caused by researchers failing to provide clear definitions of the constructs and terminology that are central to their studies. Definitions are given here of mathematics achievement, mathematics self-efficacy, theory-of-intelligence, and intelligence itself. *Mathematics achievement* is defined as a student's level of attainment in mathematics skills, as estimated by their performance on a sample of items from a standardised test. Also directly related to mathematics, an individual's *mathematics self-efficacy* is their judgment of their ability to successfully solve specific mathematics problems (Pajares, 1996a). A more general construct than mathematics self-efficacy, a person's *theory-of-intelligence* is their belief about the malleability of intelligence – whether they believe that intelligence is a fixed entity (an *entity belief*), or that intelligence can be increased through applying effort (an *incremental belief*) (Dweck & Leggett, 1988). Defining *intelligence* proved more challenging. Drawing on Sternberg (1985a), intelligence is conceptualised as comprising three dimensions: one, the complexity of knowledge and skill that can be learned in a given domain; two, the capacity for such learning; and three, the rate at which such knowledge and skill can be acquired.

The New Zealand mathematics education context

For the first decade of this century, primary teachers' professional development in mathematics was driven by the goal of improving student achievement by building teachers' professional capability. This goal was the New Zealand government's response to poor student achievement results in the *Third International Mathematics and Science Study* (Garden, 1997). This study was the first international study to compare the mathematics performance of New Zealand 9 and 13-year-olds to that of their peers in 45 other countries, and it broke new ground in that previous studies had not included primary students. The relatively poor achievement of our students on tasks that involved an understanding of place value, fractions and proportions, or measurement was of particular concern.

In 1998, an initial response was for the government to set up the Mathematics and Science Taskforce, which recommended professional development programmes that targeted teachers of Year 3 students and focused on teaching number concepts, in particular, place value. Year 3 was seen as a critical period for the

development of place value concepts, at a time when international results (Garden, 1997) combined with findings from earlier New Zealand studies of number learning (for example, Young-Loveridge, 1991, 1993) to give a picture of slower-than-expected progress for 7 to 9-year-olds.

The government also brought together an expert group to advise them on how to achieve their nebulous goal of every child turning nine being "able to read, write, and do maths for success" by 2005 (Ministry of Education, 1999, p. 1). A key recommendation from this government group that was implemented was to make it a legal requirement for schools to make literacy and numeracy a greater focus in the first four years of primary school[1].

Building on the professional development that was being undertaken with Year 3 teachers, and initially drawing on what was at that point a remedial mathematics programme, *Count Me In Too* (Department of Education and Training, NSW, 1998), pilots of components of the Numeracy Development Projects were conducted from 2000 (Higgins, 2002; Irwin & Niederer, 2002; Thomas & Ward, 2001). During the Numeracy Development Project's first phase until 2009, the projects were gradually implemented up to secondary school level (Irwin, 2003, 2004), and in English and Māori-medium classrooms (Christensen, 2003, 2004) with an annual evaluation cycle supporting their development and refinement over this time.

The focus of professional development for teachers was on both their personal mathematics content knowledge and their pedagogical content knowledge, supported by the provision of a series of booklets for teachers. The first booklet presented the Number Framework (see Ministry of Education, 2008a for the most recent iteration), which provided teachers with a framework of likely stages describing students' progress towards increasingly sophisticated number strategies and knowledge. The framework drew on the work of Steffe (1994) and Wright (1998), who had developed learning pathways for early number learning that took developmental trajectories into account.

[1] In New Zealand, children attend primary school (Years 1 to 8) between approximately 5 and 12 years old, many having the option of attending a separate intermediate school for the last 2 years of this time. Where primary students are referred to here, it represents students within this age range.

In the Numeracy Development Projects, *number strategies* were defined as mental processes that students use to solve number problems involving operations (addition, subtraction, multiplication, and so on), and *number knowledge* referred to the key items of knowledge, such as basic facts and place value knowledge. As each of the ordered stages (up to eight in some domains) became more advanced, progressively more sophisticated mathematics had to be learnt. Subsequently, the revised national curriculum (Ministry of Education, 2007) incorporated the Number Framework, aligning stages on the framework with curriculum levels and making its implementation mandatory for all New Zealand schools.

A second, closely-related feature of the Numeracy Development Projects was the assessment of individual students by the teacher, using a scripted diagnostic interview (Ministry of Education, 2008b). Undertaking this assessment was originally intended as professional development for teachers[2], helping to acquaint them with the range of student behaviours that were consistent with each stage of the Number Framework. However, it was the data from these interviews that were analysed as part of the on-going evaluation and which informed the continued review and development of the implementation and support materials for teachers (Higgins & Parsons, 2011).

The end of phase one coincided with the introduction of national standards in mathematics (Ministry of Education, 2009). The standards are now mandatory, having been incorporated into the National Administration Guidelines (available at www.minedu.govt.nz). There has, however, been resistance from some schools to the introduction of the national standards, with much of the debate centering on concern about the potential for the use of student data to compare schools, teachers, and students. The possible effects of labelling students as being below the standard for their year have also been the topic of much discussion, as has the perception of increased workload for teachers. At the same time, national standards sit comfortably alongside existing assessment and reporting practices in some schools, where they have been accepted as a means of strengthening teachers' communication with families about students' learning, and supporting the identification of students whose achievement is below the expectation for their age.

[2] Some schools have made the decision to provide resources for teachers to complete these interviews with every student at either the start or end of the school year, as the detailed information that teachers gain about their students is helpful in developing teaching programmes and reporting students' progress.

Since 2010, the second phase of the Numeracy Development Projects has focused on their in-depth sustainability, with facilitators supporting schools to incorporate the curriculum and national standards requirements into mathematics programmes that result in improved learning outcomes for students.

Such was the concentration on the on-going development of this initiative that only relatively recently has Ministry of Education funding been available to explore the effects of other mathematics interventions with primary students. A group of Ministry of Education-funded intervention studies, collectively named "Accelerating Learning in Mathematics" (see Neill, Fisher, & Dingle, 2010) was trialled in 39 schools around New Zealand during 2010. These interventions aimed to accelerate learning for students who were achieving below expectations for their year in mathematics. Each intervention involved collaboration between a numeracy facilitator and a teacher (or teachers) who developed an intervention for targeted students' identified learning needs. Each school had input into deciding a specific focus for their number intervention, with basic facts and place value the two most commonly chosen foci. Evaluation of the various interventions was based on the results of two assessments: the Numeracy Development Projects' diagnostic interview (Ministry of Education, 2008b), and *Progressive Achievement Test: Mathematics* (Darr, Neill, & Stephanou, 2007), a multi-choice test. Results indicated that the achievement of students increased "by an average of eighty per cent of a year's growth over the ten weeks of the intervention" (Neill et al., 2010, p. v). One of the factors to which participating teachers and facilitators attributed students' improved achievement was anecdotally reported as "increased student confidence and self-efficacy" (p. v). However, the evaluation of these studies did not include an exploration of the association between data that were gathered on changes in students' attitudes towards mathematics and changes in their achievement; no mathematics self-efficacy data were collected. Like the Numeracy Development Projects, these interventions directly targeted students' mathematics understandings, and did not explicitly intervene to change students' beliefs.

Other recent mathematics education research in this country, much of which was associated with the Numeracy Development Projects evaluation research, has added to what is known about teaching and learning mathematics by incorporating students' viewpoints. Such studies have included: students' perspectives on communicating their mathematical thinking (Young-Loveridge, Taylor, & Hāwera, 2005); what students think mathematics is about (Walls, 2007; Young-Loveridge,

Taylor, Sharma, & Hāwera, 2006); the views of Māori students about learning mathematics/pāngarau (Hāwera, Taylor, Young-Loveridge, & Sharma, 2007); and Māori students' views on the use of equipment in mathematics (Hāwera & Taylor, 2010). Investigating students' interactions with teachers during mathematics lessons has been a particular focus in studies of discourse in mathematics classrooms (Hunter, 2007; Irwin & Woodward, 2005), patterns of teacher-student interaction (Higgins, 2003), and teacher-student questioning (Bonne & Pritchard, 2007). Teacher-student feedback practices during mathematics lessons have been described (Knight, 2003) using the typology devised by Tunstall and Gipps (1996a), in a study that was descriptive and explanatory in nature, rather than interventional.

Explicit investigation of ways in which primary students' self-beliefs are associated with their achievement in mathematics appears to be lacking. One study (Thomas & Tagg, 2009) touched on this by surveying 83 Year 7 students' attitudes about learning mathematics and describing connections between students' attitudes and achievement. In their synthesis of studies that provided evidence of what is thought to constitute effective mathematics pedagogy, Anthony and Walshaw (2007) acknowledged the important roles played by students' confidence, motivation, and self-efficacy in their association with achievement. To date, however, no New Zealand study has investigated how interventions that aim to change primary students' beliefs about learning might be associated with improvements in mathematics achievement.

Primary students' mathematics achievement

In New Zealand primary classrooms, student achievement is measured in relation to a variety of reference points. Primary teachers monitor students' mathematics learning in relation to specific learning intentions, usually derived from curriculum expectations (Ministry of Education, 2007), to identify individual students' progress and any misconceptions they might have, and to pinpoint their future learning needs. Learning intentions may be developed by teachers to address an identified learning need among their students, so may vary from class to class, and from school to school. One of the advantages of the recently-introduced national standards (Ministry of Education, 2009) is that they have the potential to provide key reference points, linked to curriculum levels, which will be more uniform across the whole of New Zealand.

Achievement information can also be used to group students for mathematics instruction, either within a class, or by cross-grouping between classes of similar age groups. In New Zealand primary schools, a student's achievement in mathematics and reading is often a key consideration when devising class groupings, allowing teachers to combine individuals with similar learning needs in instructional groups. Such ability-based grouping is perceived to be a way of meeting students' academic learning needs (Dharan, 2010). As students reach secondary school, where mathematics, along with science, is typically perceived as an academically difficult subject, ability-based differentiations become more pronounced. Traditionally, achievement in mathematics at secondary school has been a filter for entry to tertiary mathematics courses, and then to the high-status careers for which such courses are prerequisites (Betz & Hackett, 1983). Stinson (2004) described mathematics as a "gate-keeper for economic success, full citizenship, and higher education" (p. 11).

Although international comparisons of student mathematics achievement such as the *2007 Trends in International Mathematics and Science Study* (Gonzales et al., 2008) indicated overall improvements for New Zealand Year 4 students from 1994 to 2007, this has made little difference to our country's international ranking, particularly in the area of number. Over a 10-year period, the Numeracy Development Projects spearheaded substantial changes in mathematics teaching, and their impact on primary student achievement was closely monitored at a national level (for example, Thomas & Tagg, 2009; Thomas, Ward, & Tagg, 2010; Young-Loveridge, 2009, 2010).

Although there has been evidence of students making substantial progress, particularly in the additive and multiplicative domains (Young-Loveridge, 2010), the achievement of students in particular groups continues to be of concern. Ministry-funded evaluation research has shown that during the first year of this initiative in schools, students have made substantial progress in some areas, but that not so many students in Years 6-9 are attaining curriculum expectations for their year (Young-Loveridge, 2008, 2009, 2010). Consistent with this, in 2009 38% of the 78 Year 8 students in Thomas et al.'s (2010) longitudinal study were achieving below the Ministry of Education's expectations. This has raised questions about whether the curriculum expectations are perhaps set unrealistically high, and whether it is reasonable to expect students at this level to make greater progress than they have been making. However, using the combined data for 307 students from 2006, 2007,

and 2008, Johnston, Thomas, and Ward (2010) found that Year 8 students had actually made quite steady progress in number strategy development over that time. This progress only became apparent when students' data were calibrated to a Rasch measurement scale, rather than progress being counted in discrete stages on the Number Framework.

Young-Loveridge (2010) suggested that treating the stages on the Number Framework – particularly the early stages – as equal, was a misconception among some teachers. As a result, these teachers' expectations for student achievement might not have been sufficiently high, especially in the first years of school where teachers should be "moving through those early stages at a reasonably brisk pace" (p. 31). If this is the case, then further teacher education about implications of the Number Framework for classroom teaching may be necessary.

Looking at how achievement might be associated with ethnicity, the 2007 data indicated the achievement of Māori students continued to trail that of students of European descent (Ministry of Education, 2008c), with Māori students proportionally over-represented among those who were identified as *below* or *well below* the expectations for their age[3]. In the 2008 end-of-year data, Māori students' average stages on various domains of the Number Framework continued to be lower than those of New Zealand European students (Young-Loveridge, 2009). Māori and Pasifika students tend to be disproportionately represented in low decile[4] schools, so distinguishing the effects of ethnicity from those of socio-economic level is difficult. However, Young-Loveridge (2010) compared the numeracy stages of Māori students in low and high-decile schools, and showed that being in a low-decile school appeared to compound the disadvantage for Māori students.

Since the year 2000, the New Zealand government has made a significant financial investment in the Numeracy Development Projects with the aim of building teachers' professional capability in order to raise student achievement. The additional imperatives of a new curriculum and national standards for mathematics

[3] Students who are identified as being *below* are one year below the expectation; those who are *well below* are those whose achievement is below the expectation by more than one year.

[4] A school's decile is an indicator of the proportion of students a school draws from low socio-economic communities, with decile 1 schools having the highest proportion and decile 10, the lowest.

have strengthened this focus. Teachers around the country have worked to implement these changes in their mathematics teaching practices, and after an initial improvement in overall achievement, further gains have proved more difficult.

Assessing students' mathematics achievement

Assessment can vary in its purpose, form, and formality. Assessments of students' mathematics achievement can be used for diagnostic or formative purposes (Black & Wiliam, 1998); to determine what a student knows or can do; to inform instructional groupings, planning, goal-setting; and to provide feedback to the student. Assessments can also be used for summative purposes, to provide a summary of performance for reporting purposes. In primary schools, assessment can include teacher-student conferencing, verbal or written peer and self-assessment, and recorded ideas in the form of work samples (including photos) and tests. Informal assessments can include teacher-student conversations, or a teacher's incidental observation of a student interacting with peers in the playground. At the more formal end of the spectrum, assessments can take the form of timed written tests, completed individually in silence.

A range of assessment tools has been developed in New Zealand to estimate primary student achievement in mathematics. Several of these were developed from the work of Wright (1998) to support the Numeracy Development Projects, key among which was the one-to-one diagnostic interview (Ministry of Education, 2008b). With young students, the interview might be shorter than 10 minutes, but in the case of students whose mathematics understandings are very advanced, it is not unusual for an interview to last more than 30 minutes. So while teachers complete the diagnostic interview with each of their students, they generally need a colleague to teach their classes, which in most schools is not financially feasible over the long term. Because of this disadvantage of the full interview, the Global Strategy Stage assessment and Knowledge Assessment for Numeracy were both developed as a shortened form of the interview, and can be administered during a mathematics lesson to assess individual students' number strategies and knowledge, respectively. These assessments provide teachers with an approximation of a student's stage on the Number Framework, and yield less reliable data than the full diagnostic interview.

One of the difficulties associated with the assessments for the Numeracy Development Projects has been interpreting student achievement data in

meaningful and consistent ways. The full diagnostic interview (or its proxies described above) provides information regarding the stages on the Number Framework at which a student is operating across the various domains, such as addition and subtraction, or multiplication and division. Although the numbered stages represent an ordered learning progression, the intervals between the stages are not uniform, making these data ordinal in nature. This characteristic of the structure of the Number Framework has made comparison of data from one year to the next problematic, an issue that Johnston et al. (2010) addressed by calibrating data to a measurement scale.

Other assessment tools created to support New Zealand teachers include two that comprise collections of individual assessment items. The *Assessment Resource Banks* (available at http://arb.nzcer.org.nz/) are a large collection (around 3,000) of free assessment items for mathematics, science, and English, available online. The items were designed to provide teachers with some diagnostic information related to students' responses, including common misconceptions. Individual items can be used to monitor students' achievement of a specific learning intention, or groups of items can be amalgamated to create a written test. *Assessment Tools for Teaching and Learning* (e-asTTle) is another Ministry of Education-funded assessment resource. It is an electronically-available assessment tool (see http://e-asttle.tki.org.nz/) that allows teachers to create their own written tests, which can also be completed by students online. A variety of reports of results can be produced, and it allows comparison of student outcomes with national norms. Both of these tools are collections of individual items that teachers can assemble as they see fit, rather than a set written test.

A collection of set written tests that is widely used in New Zealand is the *Progressive Achievement Test: Mathematics* (Darr et al., 2007), designed for use with Year 3 students and upwards. Each year-appropriate assessment is a multi-choice, written test that can be readily administered with a whole class of students at the same time. Other progressive achievement tests are available to assess reading comprehension and vocabulary, and listening comprehension. Since the 1960s, New Zealand primary schools have administered these near the beginning of the school year to provide information for planning mathematics programmes and to report to parents. Following their revision in 2006, the updated mathematics tests were aligned with the Numeracy Development Projects' stages as well as the curriculum levels (Ministry of Education, 2007). Strengths of these standardised assessments are the reliability and validity of

the data (see Darr et al., 2007, p. 27 for details), and the ability to administer the assessment with a whole class. By applying a Rasch measurement model (Rasch, 1980), a student's total score locates their achievement on an interval scale – the "PAT: Mathematics scale" (Darr et al., 2007, p. 22) – allowing their progress to be tracked from year to year on the same scale. Furthermore, the difficulty of individual items has been mapped against this scale, furnishing specific information about item difficulty. Online reports of individual and class achievement results, broken into mathematics domains, can support teachers to plan for students' learning needs and report to parents.

Using collections of these items that have been statistically calibrated for difficulty has the potential to yield fairly precise measurements of students' mathematics self-efficacy beliefs to be made. For instance, when a student strongly agrees that they can solve a problem with a low difficulty level, it does not convey the same information as the same response for a very difficult problem. Previous studies (for example, Ramdass & Zimmerman, 2008; Relich, DeBus, & Walker, 1986; Schunk & Hanson, 1989) have used number problems or problem types of varying difficulty, but including more specific information about where individual items are located on a difficulty scale was intended to add to the rigour of the present study's findings.

One final feature of the assessment landscape in New Zealand is the national standards for reading, writing, and mathematics (Ministry of Education, 2009) that were implemented in New Zealand schools in 2010. These involve teachers making overall judgments about a student's achievement relative to individual standards in these key learning areas. Teachers' judgments may incorporate students' performance on formal assessments, although the prime source of information is intended to be teachers' observations of students when working with the teacher, and when working independently. The intention is that by monitoring students' achievement against national standards, students who are not achieving the expectations for their year can be identified early and teachers and schools can devise ways to support those students' learning. The implementation of national standards has also emphasised regular "plain English" reporting to parents of their children's achievement in literacy and mathematics. The Ministry of Education has been developing support materials to help teachers use moderation processes to consistently align their judgments of student achievement of the standards with – in the case of mathematics – stages on the Number Framework and therefore approximate curriculum levels, and performance in *Progressive Achievement Test: Mathematics* and e-asTTle.

Students' beliefs about learning mathematics

The present study of primary students' mathematics self-efficacy and theory-of-intelligence was intended to help build our understanding of how students' perceptions of their "personal success and capability" (Ministry of Education, 1999, p. 3) are associated with their achievement in mathematics. Although there is an array of assessment tools available to New Zealand teachers to furnish estimates of student *achievement* in mathematics, instruments to measure students' *self-beliefs as learners* of mathematics are not presently available. A small number of psychological tests are available to gauge primary students' more general self-concept, self-esteem, and emotional literacy (see http://www.nzcer.org.nz/tests).

An emphasis on the importance of students' self-efficacy and beliefs about the malleability of intelligence has been implicit in recent Ministry of Education publications that have shaped education in New Zealand. The *Report of the Literacy Taskforce* (Ministry of Education, 1999) stated that, "Student achievement is influenced by personal, cultural, family, and school factors. Feelings of personal success and capability, as well as personal interests and liking for a subject, have a strong bearing on progress and learning outcomes" (p. 3). In the current curriculum document (Ministry of Education, 2007), the key competencies include "Managing self", which "is associated with self-motivation, a 'can-do' attitude, and with students seeing themselves as capable learners" (p. 12). However, the key competencies do not have specific achievement objectives as do the learning areas such as the arts, social sciences, and mathematics. Although the role of students' motivation and self-belief is alluded to in these documents, there are no explicit messages that compel any action in this regard.

Teachers are expected to report on students' progress with reference to curriculum expectations, and more recently, national standards. Because there are no curriculum expectations or national standards related to students' self-beliefs, these are unlikely to be monitored by teachers, and most teachers probably have neither evidence of how their students see themselves as learners of mathematics, nor strategies with which to respond to students' reported perceptions. In line with the curriculum's focus, recent professional development programmes and development of assessment instruments have concentrated on mathematics *content*, rather than on students' *beliefs*.

The researcher's background

A background of primary teaching, mathematics education, and mathematics-related research contributed to the foundation from which I undertook this study. My experience over a number of years as a primary-school teacher, lecturer in primary mathematics education, and facilitator for the Numeracy Development Projects, gave me a depth of knowledge related to teaching mathematics to primary students, and to teaching teachers. In order to apply this in a school setting, in 2004 I took up a teaching role that included the leadership of mathematics in a large, suburban primary school, where I later became assistant principal. Responsibilities included teaching groups of students who were identified as gifted and talented in mathematics, and students who were struggling to keep up with their peers in this important learning area. While there, I pursued my interest in research by collaborating with a university-based researcher and a group of teachers across a small group of Wellington schools to investigate the nature of the questions teachers ask during mathematics lessons (Bonne & Pritchard, 2007). Teacher-student interactions were also important in the present study, which investigated ways in which these can be shaped to strengthen students' beliefs about learning mathematics, with the goal of increasing their achievement.

The present study was motivated by my experience of teaching groups of 7 and 8-year-old students who had been identified by their teachers as achieving below the expectation for their age, and who were withdrawn from their classrooms for remedial mathematics lessons. Although diagnostic assessment information indicated that these students should have been able to successfully complete the mathematics activities with which they were presented, they were initially reluctant to engage with them, and it seemed likely that for these students to improve their achievement in mathematics, something more than their understanding of mathematics concepts needed to be attended to.

CHAPTER 2
Students' Mathematics Self-efficacy

> Educational practices should be gauged not only by the skills and knowledge they impart for present use but also by what they do to children's beliefs about their capabilities, which affects how they approach the future. Students who develop a strong sense of self-efficacy are well equipped to educate themselves when they have to rely on their own initiative. (Bandura, 1986, p. 417)

Theoretical underpinnings of self-efficacy

Simon (2009) described the use of theories in mathematics education research as using lenses through which particular aspects of research might be illuminated, while others are left in the shadows. The use of multiple theories can shed light on a given situation from different angles, providing a better explanation than a single theory might (Cobb, 2007).

Theories of learning seek to explain the complexities of learning and to demonstrate predictive power, and have the potential to help identify ways in which behaviour might be modified to improve learning outcomes. The seeds of social cognitive theory can be traced back to at least the 1940s, when social learning theory (Miller & Dollard, 1941) explained learning as a combination of drives, cues, responses and rewards, and included the role of observation and imitation in the learning of animals and people. At the time, it gained little traction due to the dominance of behaviourist theory, which asserted that an organism's behaviour is shaped by a combination of external stimuli in their environment and inherited characteristics. Also somewhat overshadowed at the time by behaviourism, Maslow (1943) developed a theory of motivation, based on a hierarchy of needs that must be met in order for an individual to achieve full psychological maturity (self-actualisation).

The 1950s saw a move away from behaviourist theory towards both humanistic psychology, of which Maslow is often referred to as the father, and cognitive psychology, associated with Chomsky. Around that time, Skinner's radical behaviourism was strongly criticised by Chomsky (1959), and the next two decades saw something of a renaissance of interest in cognition, motivation and affective processes, and the role of self-theories in psychology.

Social learning theory – later expanded and renamed social cognitive theory – was originally based on tenets drawn from behaviourist operant conditioning. Then in

the 1970s Bandura distanced himself from behaviourism because, he claimed, it "reduces individuals to passive respondents to the vagaries of whatever influences impinge upon them" (1977a, p. 6). Furthermore, he stated, "A theory that denies that thoughts can regulate actions does not lend itself readily to the explanation of complex human behaviour" (p. 10).

By the 1980s, Bandura's programme of research had expanded beyond a focus purely on learning, and social cognitive theory was well-established, proposing that a person's individual agency, cognitive functioning and self-beliefs played important roles in determining behaviour. By then, neo-behaviourists (for example, Wheldall, 1987) were incorporating a cognitive element into their theory. During this decade, there was an increase in the focus on cognitive processes and information-processing views of learning that had been a parallel stream since the 1960s, and the focus on the self waned. This was partly in response to perceptions about falling academic standards and the need to prioritise raising achievement. More recently, studies involving self-theories have increased, perhaps partly due to increased research into brain functioning, supported by advances in technology.

Social cognitive theory

Social cognitive theory is most closely associated with the work of Bandura (1977a, 1977b, 1978, 1986), and seeks to explain human behaviour as a product of direct and indirect learning. Direct learning – also referred to as trial-and-error learning – occurs when the learner's behaviour is reinforced by rewards or punishments. Indirect learning – also referred to as vicarious learning and observational learning – occurs when the learner changes their behaviour without external reinforcement. In social cognitive theory, a distinction is also made between learning and performance, with the underlying thinking being that learning can occur by observing, but that what is learnt may not necessarily ever be performed.

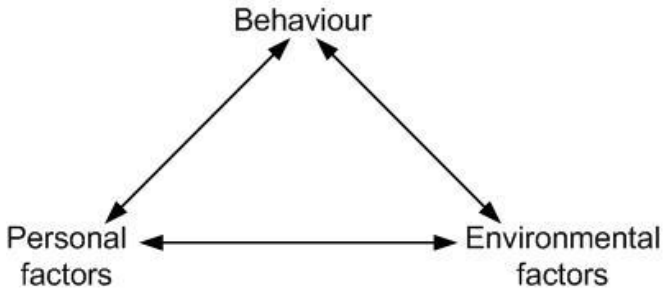


Figure 2.1. Bandura's (1978) triadic reciprocal causation.

Central to social cognitive theory is the tenet of triadic reciprocal causation (Bandura, 1978) (see Figure 2.1), which refers to the interactions of behaviour, internal personal factors (cognitive, affective, and biological states), and external environmental factors. An important feature of triadic reciprocal causation is that the individual is conceptualised as having opportunities to exercise some control over their life, rather than the environment and genetic inheritance on their own determining a person's destiny. In this dynamic relationship, different factors will have greater influence on other factors for different people, in different situations. Furthermore, it can take some time for a factor to exert its influence. As Bandura (1986) pointed out,

> Because the triadic factors do not operate simultaneously as a wholistic entity, it is possible to gain some understanding of how different segments of two-way causation operate without having to mount a Herculean effort to study every possible interactant at the same time. (p. 25)

This is of particular relevance in the present study, where identifying relationships between personal factors and behaviour, and the effects of interventions that target environmental factors, was the focus. In the present investigation, the position is taken that the effect of teacher strategies such as the use of feedback (environmental factor) on students' mathematics self-efficacy and theory of intelligence (personal factors) is mediated by students' interpretation of and reaction to those strategies (behaviour). Although Bandura (1977a) claimed that behaviour, personal factors, and environmental factors "all operate as interlocking determinants of each other" (p. 10), the direct influences of personal and environmental factors on one another are not a focus of the present study.

In social cognitive theory, achievement behaviours are influenced by a number of personal factors, key amongst which is a person's self-efficacy – the focus of this chapter. The attributions a person makes for their successes and failures will be included in the discussion of self-efficacy, so an overview of attribution theory is presented next.

Attribution theory

Attribution theory is included here because it is needed to explain aspects of self-efficacy and theory-of-intelligence (discussed in Chapter 3). Like triadic reciprocity (Bandura, 1978), attribution theory can also be conceptualised as interactions of behaviour, personal factors, and environmental factors. Heider's (1958) work

included an attributional approach that distinguished between “factors within the person and factors within the environment” (p. 82). In the following decade, this was strengthened by Rotter’s (1966) focus on internal/external factors, and then was further extended in the 1970s to include stability and controllability as factors (Weiner, 1979; Weiner, Heckhausen, Meyer, & Cook, 1972). The four causes to which achievement success or failure is most often attributed were identified by Weiner (1979) as ability, effort, luck, and task difficulty, and to this list Clifford (1986) added the use of learning strategies. More recently, Dweck (2000) expanded on Weiner’s (1979) ideas relating to the internal attributions of ability and effort to develop the concept of theory-of-intelligence.

Weiner also devised three dimensions of attributions. The first is the location of responsibility for the outcome in relation to the student – internal or external – and builds on Rotter’s (1966) work on the locus of control. Internal factors include ability, effort, and use of learning strategies, and external factors include task difficulty and luck. The second dimension differentiates stable and unstable causes according to how variable the perceived cause might be over time. Attributions vary in stability; unstable causes are attributed to temporary factors, such as succeeding with an assignment due to having extra help, while other causes are stable, such as an improved basic facts test score due to constant practice. The last dimension is the degree of control a student perceives they have over a cause. Luck is clearly an uncontrollable factor, while effort, on the other hand, is considered controllable.

Understanding the difference between concepts of effort and ability is also important to attribution judgments, and Nicholls’ (1978) development of four levels of reasoning helped explain this (Nicholls’ levels are described in greater detail in the following chapter, in the section, *The development of students’ conceptions of intelligence and ability*). The research in this area in the late 1970s explored differences between the sexes. For instance, Nicholls (1978) found that boys tended to have higher self-concepts of ability and were more likely than girls to choose to tackle a challenging mathematics task. He noted that boys’ confidence levels were “probably unrealistically higher” (p. 810). Dweck and Bush (1976) found some striking differences in the responses of girls and boys to feedback after failure, and to their predominant attributions. When girls were given feedback by an adult, they tended to attribute their failure to lack of ability, whereas boys tended to do this when the feedback came from one of their peers.

Attribution theory plays an important role in perceptions of self-efficacy by explaining how people account for behaviour and outcomes. In order to form efficacy assessments when a task is successfully completed, Schunk (2008) proposed that students consider ability, effort expended, task difficulty, how much help they needed, and their track record of successes and failures, as well as whether or not the student perceives the task to be worthwhile. If a student found a task very easy, for instance, and completed it successfully with a minimum of effort, this might have little impact on their self-efficacy. Similarly, a failure that can be attributed to events outside the student's control is likely to have only a slight effect on self-efficacy.

Self-efficacy is connected to social cognitive and attribution theories. In social cognitive theory, individuals' self-beliefs are critical to their motivation and achievement, and involve their forming beliefs about what they can do, setting goals for themselves, anticipating likely outcomes, and planning courses of action to achieve their goals. Attribution theory helps to explain why a student's self-efficacy might be influenced by the outcomes they achieve. In this way, a student's self-efficacy is postulated to influence, and in turn be influenced by, achievement.

Disentangling self-efficacy from other self-constructs

In the self-efficacy literature, other self-constructs are sometimes confused with self-efficacy. Ill-defined terminology and unclear differentiations in ways constructs are operationalised has plagued studies of self-constructs for many years. In 1968, Wylie commented on the need for "more clearly differentiated literal meanings and correspondingly differentiated operational definitions" (p. 753). More recently, Bong and Skaalvik (2003) have pointed out, "[A]cademic motivation researchers sometimes struggle to decipher the distinctive characteristics of what appear to be highly analogous constructs" (p. 1). A case in point is the tendency in the literature to confuse self-concept, self-esteem, and self-efficacy.

Bandura (1986) defined self-efficacy as:

> … people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses. (p. 391)

The various ways in which researchers have interpreted this definition have resulted in its meaning sometimes seeming remarkably similar to other self-constructs, further blurring the distinctions between constructs that already tend to overlap. These different interpretations have implications for the assessment of self-efficacy.

Self-efficacy and self-concept seem to be closely-related constructs, similar to one another in that they both draw on self-evaluation of past performances, and also because perceived competence contributes to both. To varying degrees, both have been shown to predict achievement, as described in Valentine, DuBois and Cooper's (2004) meta-analysis. At the domain-related level, Pajares (1996a) suggested that the two might in fact be indistinguishable, according to evidence from a study involving secondary students (Skaalvik & Rankin, 1996). However, Pajares and Graham (1999) conducted an observational study that measured 11-year-olds' mathematics self-efficacy and self-concept at the start and end of the same year, and found the latter to be more stable than the former. They reported that, after controlling for self-concept, "mathematics self-efficacy was the only motivation variable to predict mathematics performance both at the beginning and end of year" (p. 133).

Bong and Skaalvik (2003) explained that the two constructs differ in some important ways. Self-concept, they suggested, involves an aggregated judgment, is oriented towards the past, and is thought to be fairly stable over time. It is sometimes assessed with items that ask students to make social comparisons, such as "Compared to others my age I am good at mathematics classes" (Marsh, 1999, p. 2). Self-efficacy, on the other hand, is a context-specific judgment that Bong and Skaalvik described as future-oriented, and more malleable than self-concept. The malleability of self-efficacy beliefs was illustrated by the results of Schunk's (1981, 1983a, 1983b, for example) experimental studies that identified increases in primary students' self-efficacy over short time periods, typically less than a week. The lack of evidence from experimental studies of self-concept (Bong & Skaalvik, 2003) makes it difficult to be certain how malleable it might be in comparison to self-efficacy.

Self-concept and self-efficacy vary in specificity and abstraction. To illustrate the difference between these two constructs, when a person makes a judgment about their general academic ability, they are thought to be evaluating their self-concept,

and when they judge whether or not they will be able to correctly solve a given set of mathematics problems, they are evaluating their (in this instance, mathematics) self-efficacy. However, the lines become blurred when researchers (for example, Bong, 2006; Meyer, Turner, & Spencer, 1997) talk about mathematics self-efficacy as referring to a student's perception of their ability to succeed in the subject of mathematics, thereby demanding a future-focused, but aggregated judgment of their abilities in a wide variety of mathematics contexts. Context-specific self-efficacy beliefs have been found to have greater predictive power for future achievement than do aggregated self-concept beliefs, and in fact, task-specific self-efficacy beliefs are even more accurate predictors (Pajares & Kranzler, 1995; Pajares & Miller, 1994, 1995).

Self-efficacy judgments relate to a person's perceptions of what they can do – their task-specific capabilities – rather than a person's overall affective evaluation of their self-worth and the degree to which their behaviour matches their personal standards, otherwise known as self-esteem (Gist & Mitchell, 1992; Schweinle & Mims, 2009). For example, a mathematician may have low self-efficacy for singing, but because this may be quite acceptable to them, it does not necessarily diminish their overall feelings of self-esteem, or affect their perception of themself as a mathematician. Although there appears to be no consistent association between self-esteem and self-efficacy, Bandura (1986) pointed out that "in many of the activities people pursue, they cultivate self-efficacies in what gives them a sense of self-worth" (p. 410). It is when self-efficacy is interpreted as a global self-belief that distinguishing it from self-esteem is likely to become more difficult (Chen, Gully, & Eden, 2004). Self-efficacy is a specific and contextualised judgment, made with reference to a particular goal, yet to be achieved. Its malleable nature has implications for teachers – through their interactions with students they can influence self-efficacy positively or negatively.

Issues of interpretation and assessment

Ways in which the construct of mathematics self-efficacy is interpreted by a researcher have implications for how it is assessed. To operationalise mathematics self-efficacy as a measurable entity, Bandura (1986) recommended that its assessment should require students to judge their ability to use the skills that are demanded by the performance tasks with which it will later be compared. Pajares (1996a) emphasised that for a measurement of self-efficacy to be reliable, it should

require students to make judgments about their ability to solve specific problems, rather than to make global judgments about how able they judge they are to do mathematics in general:

> Domain-specific assessments, such as asking students to report their confidence to learn mathematics or writing, are more explanatory and predictive than omnibus measures and preferable to general academic judgments, but they are inferior to task-specific judgments because the subdomains differ markedly in the skills required. (p. 547)

As Skaalvik (1990) noted, Bandura's (1977b) definition of self-efficacy has been interpreted in different ways. Most of the empirical studies that included a measure of mathematics self-efficacy fall into two groups: those that interpreted mathematics self-efficacy beliefs as relating to specific mathematics problems or problem types, and those that interpreted these beliefs as relating to mathematics as a domain.

Task-specific assessment of mathematics self-efficacy

In 20 studies, predominantly from the US and dominated by Schunk and his colleagues (Anjum, 2006; Bandura & Schunk, 1981; Lloyd, Walsh, & Yailagh, 2005; Norwich, 1987; Pajares & Graham, 1999; Relich et al., 1986; Schunk, 1981, 1982, 1983a, 1983b, 1983c, 1984, 1985, 1996; Schunk & Gunn, 1985, 1986; Schunk & Hanson, 1985, 1989; Schunk, Hanson, & Cox, 1987; Stevens, Olivárez, & Hamman, 2006), primary students as young as 7 years old were asked for their perceived ability to correctly solve particular mathematics problems or types of problems, prior to being asked to solve similar types of problems, to give an achievement measure. Many of these studies were experimental pre-test/post-test designs that included treatments of less than one hour's duration, over consecutive days (from two to seven). Most of the studies conducted by Schunk, a former student of Bandura's, involved students whose mathematics achievement was below expectations for their age. Generally, students' scores from Likert-scale items were totalled and averaged, with the data then (spuriously) treated as continuous for statistical analysis. Data such as these have often been incorrectly treated as interval data in the literature, assuming equal differences between any two adjacent points on the measurement scale, with means and standard deviations reported, as Jamieson (2004) highlighted. More correctly, the median and mode should have been reported, along with results of non-parametric tests such as the Kruskal-Wallis which is used to test whether the medians of three or more samples are equal.

The task-specific assessment method is consistent with Pajares' (1996b) recommendation that capabilities about which self-efficacy judgments are made should be the same capabilities that are later tested. This method also yields data about students' performance, to compare with their perceptions of their abilities to correctly answer these types of questions.

More recently, a small group of studies (Chen, 2003, 2006; Chen & Zimmerman, 2007; Ewers & Wood, 1993; Klassen, 2004; Ramdass & Zimmerman, 2008; Skaalvik, 1990) has assessed mathematics self-efficacy at an even greater level of specificity. In these studies, of which only one (Ramdass & Zimmerman, 2008) is an intervention study, the maths problems that primary students were asked to judge their ability to correctly solve were the identical problems they were later asked to actually solve. This allowed direct comparison of mathematics self-efficacy for specific problems with achievement on those same problems.

What all these studies have in common is that they were underpinned by interpretations of mathematics self-efficacy that typically included some specificity. For example, Schunk (1981) defined perceived self-efficacy as being "concerned with judgments of one's capability to perform given activities" (p. 587), and then 15 years later as "personal beliefs about one's capabilities to learn or perform skills at designated levels" (Schunk, 1996, p. 360). Similarly, Anjum (2006) explained self-efficacy as a belief that one "is able to organize and apply plans in order to achieve a certain task" (p. 62). Such task-specific interpretations are consistent with Pajares' (1986c) claim that students' confidence to solve particular mathematics problems is a more powerful predictor of their actual ability to solve those same problems than is their domain-related judgment of their ability to achieve a top grade in mathematics. Based on the findings of comparative studies, such as Barrios (1985), Bandura (1986) recommended that self-efficacy should be measured in task-specific ways, as task-specific measures have greater explanatory and predictive power than global measures.

It is important to note the apparent decline in intervention studies in this area reflected in the studies described above. This trend is in line with the findings of Hsieh et al. (2005), who examined the intervention studies reported in four key educational psychology journals. They analysed articles published in 1983, 1995, and 2004, and found that in 1983, 55% of all articles were intervention studies, dropping to 47% in 1995, and then to 35% in 2004. They also noted that the duration of interventions had decreased, with 26% of interventions in the 1995

journals lasting more than one day, but fewer than 16% of the 2004 articles describing interventions that exceeded a single day. The reasons for this, they suggested, were the increasing popularity of qualitative methods coupled with the costs and perceived challenges associated with conducting intervention studies.

Domain-related assessment of mathematics self-efficacy

The second group of studies measured mathematics self-efficacy using items that related to students' perceived ability to succeed in mathematics more generally (for example, Bong, 2009; Chamorro-Premuzic, Harlaar, Greven, & Plomin, 2010; Kung, 2009; Meyer et al., 1997; Schunk & Lilly, 1984; Tait-McCutcheon, 2008). What these studies measured is a more general, domain-related interpretation of Bandura's (1986) definition of self-efficacy, resembling self-concept. Their definitions of mathematics self-efficacy were generally related to mathematics as a subject, rather than specific mathematics problems. For example, Davis-Kean et al. (2008) described self-efficacy as "beliefs about ability to perform a behavior" (p. 1257). In the only New Zealand study of primary students' mathematics self-efficacy, Tait-McCutcheon (2008) defined mathematics self-efficacy even more broadly as "the judgements we make about our potential to learn successfully and the belief in our own capabilities" (p. 507). Bandura (1986) was critical of such interpretations, and proposed that measures of such general self-efficacy basically assess students' broad belief that they can make things happen without specifying what these things actually are.

Three additional studies took an interpretation that fell somewhere between a broad interpretation and one that related to solving specific problems. Schweinle, Turner, and Meyer (2006) explained efficacy beliefs as "whether students believed that they had skills to perform mathematics tasks" (p. 278) more generally, and assessed this in relation to the overall content of students' daily mathematics lessons. Siegel and McCoach (2007) elicited students' self-efficacy in relation to judgments of their measurement skills, and Panaoura, Gagatsis, Deliyianni, and Elia (2010) asked for students' judgments of their perceived ability to work with decimals. Though their focus was narrowed from mathematics in its entirety to a given area of mathematics, no specific problems were used to elicit students' mathematics self-efficacy judgments, so students were essentially being asked to judge their ability to solve imaginary problems. What was measured in these studies cannot be meaningfully aligned with studies that have adhered to recommendations regarding

specificity (Bandura, 1986; Pajares, 1996a). Because these studies are heading towards domain-related interpretations, their results do not contribute in a helpful way to an understanding of mathematics self-efficacy.

Comparing these three different ways of interpreting and assessing mathematics self-efficacy, the task-specific approach provides students with the detail of specific problems, and students are presented with a visual representation of those problems. In contrast, the domain-related approach demands that students think abstractly about the general domain of mathematics, without particular details. Although other studies narrowed the focus slightly to a particular area of mathematics such as measurement, students were still expected to think in abstract terms, rather than in relation to concrete problems. Not only do the non-task-specific interpretations fail to comply with Bandura's definition of self-efficacy, and his recommendations for assessment, they also have implications for the age at which thinking abstractly about mathematics as a domain might become developmentally appropriate. In some of the studies mentioned above, what is being represented as self-efficacy is probably indistinguishable from self-concept.

What has emerged from analysing the treatment given to primary students' mathematics self-efficacy in empirical studies is that the interpretation of mathematics self-efficacy needs to be commensurate with any variable with which it is to be compared. So, if a student's mathematics self-efficacy is to be compared to their performance on a set of measurement tasks, then they should be asked to make self-efficacy judgments in relation to those particular problems, or a parallel set of problems. This then allows some meaningful comparison of the mathematics self-efficacy and achievement data. If, on the other hand, a wider interpretation is adopted, then students might be asked to judge their ability to achieve a top grade for the term, and this could be compared to the relatively broad term grade data and still, according to Pajares (1996b), "remain highly predictive" (p. 1). However, Pajares (1996a) also suggested that domain-related self-efficacy is probably indistinguishable from self-concept, and that "the two may be measures of the same construct" (p. 563), so the validity of using this broader type of measurement to represent mathematics self-efficacy is questionable. The proliferation of different mathematics self-efficacy assessment instruments makes comparison across studies problematic. Comparison becomes even more challenging when studies have assessed mathematics self-efficacy at varying levels of specificity, perhaps measuring entirely different constructs.

The mismeasurement of mathematics self-efficacy

An appeal of conceptualising mathematics self-efficacy as being domain related, rather than task specific, is that it has been possible for researchers to use the same items as those in a previous study, eliminating the need to pilot items each time. Examples of general academic self-efficacy assessment instruments used in the context of mathematics learning include the *Patterns of Adaptive Learning Survey* (Midgley & Maehr, 1991) that includes six self-efficacy items, subsequently used by Meyer et al. (1997). The *Motivated Strategies for Learning Questionnaire* (Pintrich & De Groot, 1990) included nine generic items for measuring self-efficacy for a given subject, later used by Metallidou and Vlachou (2007). The participants in both of these studies were 10 to 12-year-olds, by which age students are likely to be able to understand the abstract demands of domain-related assessments better than younger students might. In an investigation of the mathematics self-efficacy of students younger than this, it is appropriate to make the items more concrete and to present students with specific problems, in pictorial form where possible, as reference points for their mathematics self-efficacy judgments.

When a researcher has made the decision to interpret mathematics self-efficacy as task specific, they undertake to gauge students' mathematics self-efficacy using a range of problems that are appropriate to the students' ages and abilities, as well as the mathematical concepts that are of interest. Because this assessment is context specific, it is generally inappropriate to use pre-existing assessment instruments, and new items are typically developed. The development of mathematics self-efficacy assessment items must also take into consideration their alignment with curriculum and cultural contexts. The creation of appropriate assessments can be guided by models and instructions for constructing self-efficacy scales included in Bandura (1986, 2006), although, as Pajares and Kranzler (1995) pointed out, little use seems to be made of the guidelines provided, resulting in the mismeasurement of self-efficacy.

Having no universal items for gauging (task-specific) mathematics self-efficacy presents researchers with opportunities and challenges. Tailoring assessment items for a particular group of students has the advantages of presenting students with mathematics tasks that are meaningful in their cultural context, relevant to the target area of mathematics, and of an appropriate range of difficulty levels. As such, it can be an opportunity to generate authentic estimates of students' mathematics self-efficacy. The challenge relates to the proliferation of assessment

instruments making their alignment with one another uncertain, particularly when the difficulty of the tasks presented is not rated on some universal difficulty scale. In the present study, items with statistically tested difficulty calibrations, from the *Progressive Achievement Test: Mathematics* (Darr et al., 2007), allowed more precise measurements of students' mathematics self-efficacy beliefs to be made. For instance, when a student strongly agrees that they can solve a problem with a low difficulty level, it does not convey the same information as the same response for a very difficult problem. Previous studies (for example, Ramdass & Zimmerman, 2008; Relich et al., 1986; Schunk & Hanson, 1989) have used number problems or problem types of varying difficulty, but including more specific information about where individual items are located on a difficulty scale was intended to add to the rigour of the present study's findings.

In the measurement of latent variables such as mathematics self-efficacy, measures are only ever estimates of the target construct, and some variation must be tolerated. Where the aim is to investigate the relationship between mathematics self-efficacy and achievement, the precision of these estimates might be improved by including more exact information about the difficulty of the mathematics problems used. A judgment of low self-efficacy for a task that should be easy for a given age group, for instance, differs from a judgment of low self-efficacy for a much more challenging task. In studies that have assessed mathematics self-efficacy and achievement of primary school students, it is usually reported that the mathematics problems were of varying difficulty levels. Sometimes these relative levels are judged by teachers (for example, Ewers & Wood, 1993; Norwich, 1987) and at other times they are estimated by researchers (for example, Bandura & Schunk, 1981; Chen & Zimmerman, 2007; Schunk, 1982). For instance, Chen and Zimmerman (2007) used items that were easy, moderately difficult, or difficult, to compare the mathematics self-efficacy of Taiwanese and American students. Using problems that have been statistically calibrated for difficulty might afford a greater degree of accuracy when self-efficacy and achievement data related to that problem are analysed, and therefore has the potential to add further information to the analysis. In contrast, when mathematics self-efficacy is assessed at an abstract level, it does not allow for self-efficacy to be scaled to task difficulty to give an indication of the calibration of self-efficacy with actual achievement. What is missing from the literature is research that uses a collection of problems whose difficulty levels have been statistically rated on a continuous scale.

Looking across studies of primary students' mathematics self-efficacy, there are other factors that vary widely. Although a number of studies mention a pilot of assessment instruments prior to the research being conducted (for example, Bandura & Schunk, 1981; Ewers & Wood, 1993; Klassen, 2004; Schunk, 1982), details of what the piloting revealed are not included. Few research papers (Klassen, 2004; Relich et al., 1986) reported that a factor analysis of their mathematics self-efficacy items had been undertaken to provide evidence in relation to the extent to which their items are indeed measuring the same factor. In addition, ordinal data generated from Likert-type scales have typically been treated as quantitative, predominantly using mean scores for analysis, and statistical methods such as analysis of variance and multiple regression have been applied. In some studies (Ewers & Wood, 1993; Schunk, 1981, 1983c; Skaalvik, 1990), mathematics self-efficacy scores have been dichotomised, allowing for more direct comparison with performance success on similar, or the same, tasks. For instance, in Ewers and Wood's (1993) study with 10 to 11-year-old participants, students indicated their self-efficacy for particular problems on a 5-point Likert-type scale. The total number of problems for which they rated their self-efficacy 3 or higher was used as their mathematics self-efficacy score.

Because of the many variations and limitations of previous studies, it is important to closely examine the claims made about how primary students' mathematics self-efficacy is related to other variables – the focus of the following section.

Factors that contribute to self-efficacy

Factors that contribute to self-efficacy have been identified from empirical studies discussed in this section. The latent structure of these factors has been confirmed (Lent, Lopez, Brown, & Gore, 1996; Usher & Pajares, 2009) by testing the fit of different models to the data. Bandura (1997) listed the information sources that are thought to contribute to a student's self-efficacy in order of magnitude of effect: a student's past performances; vicarious experiences; social persuasion; and somatic (physiological and emotional) states. Although these are predominantly personal factors, there is also interaction with behaviour and environment factors. Collectively, these factors are appraised by the student to arrive at a self-efficacy judgment. Each of these factors is discussed here, with reference to relevant empirical research.

Past performances

According to Usher and Pajares (2009), a student's past performances have the greatest influence on their self-efficacy. Their multiple regression analysis indicated that mastery experiences explained more than 20 per cent of the variance in the mathematics self-efficacy of Grade 6 to 8 students. Put simply, successes tend to raise self-efficacy and failures to lower it. If a student has been successful at applying a particular skill in the past, then they are likely to believe that they will be successful at this again in the future. However, there are many nuances relating to the connection between past performances and self-efficacy, with the influence of successes and failures modulated by the attributions a student assigns to these outcomes. Generally speaking, successful performances that might have the greatest positive impact on self-efficacy are those which have demanded effort and perseverance, together with skills application, to realise an appropriately challenging goal. It is important to note, though, that the same achievement might not have the same impact on all students. Klassen (2004) suggested there would be different effects on students' mathematics self-efficacy of gaining a B grade because while this might be a notable success for one student who usually achieves a C grade, for another who is used to attaining an A grade, it might represent disappointment. Empirical testing of this point might help further explain the association between mathematics self-efficacy and achievement suggested in previous studies.

Self-efficacy also predicts subsequent achievement, so the relationship between self-efficacy and achievement is reciprocal in nature. In Bandura's (1984) paper, he highlighted a group of studies with adult participants for whom their self-efficacy beliefs were actually a better predictor of later behaviour than was past performance. In Feltz's (1982) study of 80 university students – experienced swimmers – who attempted four dives from diving boards of different heights, a path analysis showed that performance was a significant predictor of subsequent self-efficacy for diving, and that the strength of the predictive power increased for each successive dive. A similar predictive relationship was evident between self-efficacy for diving and subsequent performances. This supported the idea that the relationship between achievement and self-efficacy is reciprocal, and that as one strengthens, so should the other in something of a spiral effect. Whether or not it makes a difference if the student is learning a physical skill or an abstract concept needs to be the focus of further research before any claims can be made.

Vicarious experiences

Vicarious experiences have less impact on self-efficacy than do a student's own past performances. According to Bandura (1986), observations of success by similar peers raise a person's self-efficacy, and observed failures lower self-efficacy beliefs. Schunk and Hanson (1985) found that observation of peer models had a greater positive impact than observing teacher models on the self-efficacy of a group of primary students for whom subtraction was difficult. Schunk (1981) had already established that observing a teacher model who verbalised their thinking as they solved division problems was more beneficial to students' learning than instruction in the form of explanatory written notes. Both forms of instruction enhanced students' self-efficacy.

In 1987, Schunk, Hanson, and Cox built on this work with a pair of experimental studies. In the first, students assigned to four treatment groups completed pre-tests of their self-efficacy and fractions skills before they were shown videotapes of a teacher and a student who was learning to solve fraction problems. The peers in the videotapes varied by gender and by the behaviour they modelled – either mastery or coping behaviour. After students viewed the tapes, they rated their interest, self-efficacy for solving fraction problems, and perceived similarity to the model. In the second study, the treatments were similar except that this time, students were shown videotapes of either one or three peer models. They were then asked to nominate which of the models they perceived to be most similar to them. The findings from these two experimental studies indicated that observing either a single model or multiple models of a peer who gradually overcame initial difficulties had more positive effects on self-efficacy and performance than observing mastery models. The authors cautioned, though, that coping models might be interpreted differently by students who had experienced more success with learning than these remedial students had, and therefore might have different effects on their self-efficacy and achievement.

In a further component of their work relating to the use of models, Schunk and Hanson (1989) experimented with showing students videotapes of themselves solving fractions problems, and found that students who observed themselves modelling successful problem solving showed higher self-efficacy and performance than students who did not. The benefits of self-modelling were similar to those yielded by observing similar peers, and coping and mastery self-models appeared to be equally effective. As Schunk and Hanson pointed out, simply showing

students videotapes of themselves solving fractions problems will not, on its own, improve students' self-efficacy and achievement; instruction and feedback from the teacher are also needed to build students' mathematics self-efficacy.

Social persuasion, including feedback

Students' interactions with their parents, siblings, peers, and teachers can influence their self-efficacy. Teacher-student interactions, including verbal persuasion and feedback, have less influence on self-efficacy than either students' past performances or vicarious experiences, according to Bandura (1986). Encouragement and persuasion from teachers will be effective only if students subsequently experience success. Teachers can capitalise on this; when they encourage a student to engage in a task and the student succeeds with that particular task, the teacher can reinforce the student's self-efficacy by giving them specific feedback that describes what they did that made them succeed. On the other hand, to tell a student, "Come on. You can do it!" will not build their self-efficacy if they then perform poorly.

The difficulty of the task is a factor in determining what type of feedback might build a student's self-efficacy and also contributes to a teacher's decision about the degree of scaffolding they will provide the student as they work on a task. If a student finds a task easy, it gives them no new information about their ability, and to give them feedback about how hard they worked is unlikely to strengthen their self-efficacy (Schunk, 1983a). There is some evidence that effort-attributional feedback is effective with tasks of moderate difficulty (Weiner et al., 1972). But the more difficult the task, the greater amounts of both effort and ability that are likely to be needed for success, and to give students feedback about either effort or ability alone may lose credibility, according to Schunk.

The effects of attributional feedback to students was investigated in the 1980s, in a series of experimental studies (Schunk, 1982, 1983a; Schunk & Gunn, 1986) whose participants were all in the 7 to 11-year range and had difficulties learning mathematics. Teacher-student feedback that attributed these students' past performances to effort promoted self-efficacy and achievement, and was more effective in building self-efficacy than feedback about future effort (Schunk, 1982). However, Schunk's (1983a) study found that students given only ability-attributional feedback had higher self-efficacy and performance than students who received effort-attributional or a combination of ability and effort-attributional feedback, and

that these students in turn had better results than those in the no-feedback treatment. Schunk and Gunn's (1986) study, with fifty 9 to 10-year-olds, showed that students who attributed their problem-solving success to ability had greater improvements in achievement than those who attributed their success to effort. This might be partly related to these students' ages, at which they are likely to be developing greater clarity about the concepts of ability and effort (Nicholls, 1978). The students in these studies were all achieving poorly in the target area of mathematics, and it is possible that ability- and effort-attributional feedback from teachers might have different effects on students whose achievement is meeting, or beyond, the expectations for their age.

Relich et al.'s (1986) experimental study with 84 students (11 to 12-year-olds) who had poor division skills, comprised treatments that varied by the presence of teacher modelling and feedback that combined effort and ability attributions, for example, "'That's correct; see, you have the ability to do divisions when you try hard'" (p. 204). Thirty-minute treatment sessions were held over eight consecutive school days. Their results showed that teacher modelling alone was associated with improved student achievement and that when this was coupled with attributional feedback, self-efficacy was raised and achievement further enhanced. What cannot be discerned from their results, though, is whether students might have responded to the ability component of the feedback, the effort component, or both.

For feedback to impact on a person's self-efficacy, they must have confidence in the person giving it, according to Bandura (1986). Where the perceived credibility and expertise of the person providing feedback is high, the feedback they give is thought to influence self-efficacy. Empirical studies in this area appear to have focussed on students at the tertiary level, due in part to convenience for university-based researchers. In Crundall and Foddy's (1981) experimental study with psychology undergraduates, students performed perceptual tasks that involved tracking the path of a light using a wand. As well as timing how long they held the wand over the light, students completed a self-assessment that included estimating their total score and their certainty about their estimate (later interpreted as an indicator of their self-efficacy). Treatments varied by: the presence of an evaluator during the tasks; whether or not the evaluator was introduced to them as someone who had considerable experience in observing people undertake this task or as someone like themselves, who had never done this before; and whether or not

participants were provided with an estimated score by the evaluator. The findings indicated that the students were more accepting of evaluations made by evaluators with greater vicarious experience of a task than their own, rather than similar experience. Although no studies were located that examined the question of whether confidence in the evaluator makes a difference with younger students, it seems likely that primary students would generally have a high degree of confidence in their teachers and in the feedback their teachers give them.

The relative influence of learning goals is not yet clearly defined. Both the focus of the goal and its proximity to a student's current capabilities have been shown to be associated with self-efficacy. In a pair of studies in 1996, Schunk found that goals related to learning strategies for fractions problem solving were associated with higher achievement than performance goals, related to correctly solving given fractions problems. In addition, one of the studies involved students' self-evaluation of their problem-solving capabilities. The results showed that students' self-efficacy and skill increased where their goal was learning, with or without self-evaluation, and students whose goal was performance also experienced higher self-efficacy and skill when they self-evaluated.

Working with 7 to 10-year-olds who had difficulty with subtraction, Bandura and Schunk's (1981) experimental study found that proximal goals were associated with the most statistically significant increases in self-efficacy and achievement, compared to no goals or distal goals. Schunk's (1983b) experimental study also identified a significant main effect of proximal goals on 9 to 12-year-old students' self-efficacy for division problems. In another of his experimental studies, Schunk (1985) found that self-set goals were associated with higher self-efficacy and skill acquisition than teacher-set goals, or no goals. More recently, Schunk and Pajares (2002) have proposed that proximal and specific learning goals provide students with a yardstick against which to monitor their learning progress and success. Without clear learning goals, Schunk (1990) argued, students may not recognise the progress they have made, so goal-setting can impact positively on self-efficacy. What is more difficult to pinpoint is where achievement belongs in the ordering of causal relationships. For example, might proximal goals influence learning which then causes an increase in self-efficacy, rather than proximal goals causing increased self-efficacy which then impacts on learning? For that matter, might learning and self-efficacy develop almost simultaneously? What these studies have shown is that goals, or learning intentions as they are more commonly referred to in

New Zealand, need to be proximal and challenging, with clear success criteria. The power of goals seems to lie in their potential to inform students of their learning, which in turn can motivate students to strive to achieve their goals.

Physiological and emotional states

Finally, physiological and emotional states – coupled here because both are considered to affect the body – help to shape self-efficacy judgments. For example, physical signs of anxiety such as a rapid heartbeat or sweaty palms can undermine a student's belief that he or she can successfully complete a task (Bandura, 1986). Although this might apply to academic tasks, in relation to physical tasks – in this case, diving – Feltz (1982) found that heart rate and self-efficacy were not consistently related. Bandura (1997) also suggested that fatigue and stress might influence self-efficacy. How events are interpreted can be influenced by mood states, according to Isen (1987). High levels of anxiety can lead to task avoidance and negative self-efficacy for that type of task. By the same token, self-efficacy can be enhanced by feeling happy and relaxed. It seems likely that for different activities there may be optimal levels of arousal for performance, which may also be associated with optimal levels of self-efficacy.

Although several studies have confirmed physiological and emotional factors as contributing to self-efficacy of secondary school and university students (for example, Lent, Brown, Gover, & Nijjer, 1996; Lopez & Lent, 1992), studies that aim to elaborate how physiological and emotional factors influence the self-efficacy of primary students are lacking in the literature. This might be related in part to the difficulties associated with obtaining reliable information about younger students' emotional and physiological states. The identification of these four contributing factors – past performances, vicarious experiences, social persuasion, and physiological and emotional states – has provided a starting point for intervention studies, such as the present investigation and those described later in *Interventions to raise students' mathematics self-efficacy.*

The effects of students' mathematics self-efficacy

Bandura (1997) stated that self-efficacy beliefs:

> …influence the courses of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, their resilience to adversity, whether their thought patterns are self-hindering or self-aiding, how much stress and depression they experience in coping with environmental demands, and the level of accomplishments they realize. (p. 3)

The most relevant of these links, and the nature of their relationships, are scrutinised in the following section by examining empirical studies whose participants were primary students, wherever such studies could be located. Students with high self-efficacy are more likely to try hard, persevere at difficulty, and seek help at appropriate times, while those with lower self-efficacy are likely to exert less effort, give up easily, and seek help that will enable them to complete the task without necessarily engaging in the intended learning.

Bandura (1977b) hypothesised that self-efficacy influences how much effort a person is willing to apply. In their experimental study with 90 psychology students, Bandura and Cervone (1983) found that self-efficacy was a predictor of performance. The stronger that students' self-efficacy was for achieving their goals and the higher their dissatisfaction with a previous substandard performance, the greater were students' subsequent effort and achievement. Students with high self-efficacy were more likely to set challenging goals in Locke, Frederick, Lee, and Bobko's (1984) study, and to choose to take on more difficult levels of performance than those whose self-efficacy was low. As already discussed, the former students are also more likely to persevere with these tasks, while the latter are likely to give up more easily. Pre-requisite conditions for increased achievement might include students having clear proximal goals, and high levels of self-efficacy, which then might motivate students to apply the necessary effort. Also important is a foundation of skills on which to build, and the provision of tasks that present students with an appropriate degree of challenge.

Effort and persistence are often discussed together in the literature. They are differentiated by the manner in which they are operationalised and measured, with effort generally measured by self-evaluation (for example, Salomon, 1984), and persistence indicated by the time students nominate to spend on a challenging task (for example, Bandura & Schunk, 1981).

Empirical studies have investigated the relationship between the mathematics self-efficacy and persistence of primary students with difficulties in mathematics (Bandura & Schunk, 1981; Schunk, 1983a, 1983b, 1983c). In these studies, students were asked to solve a set of easy tasks and a set of tasks that were difficult for them. Persistence was measured by timing how long they spent on the difficult tasks. The findings, though, have been mixed. In Bandura and Schunk's (1981) study, moderate positive correlations were found between mathematics self-efficacy, perseverance, and correctly solving difficult problems. Schunk's (1982) study, however, found that as students became more skilful at subtraction, they did not spend less time post-treatment on the same easy problems they had solved pre-treatment. He suggested this might be because some students simply prefer to work slowly. Then in his 1983a study, Schunk found that post-intervention self-efficacy and skill were negatively correlated with persistence. Several factors might influence this measure of perseverance. For example, a student might spend only a short time on a problem because they quickly realise it is beyond their current understanding, because the task does not engage them, or because they do not perceive the task as worthwhile. The reasons that underpin the time spent on problems by students of a wider range of abilities needs to be clarified by further research, in particular, research that investigates the optimal gap between actual ability and self-efficacy, using calibrated items.

That mathematics self-efficacy is a predictor of achievement is well established across a range of education contexts (for example, Chen, 2003; Pajares & Graham, 1999; Pajares & Miller, 1994; Schunk, 1981; Schunk & Hanson, 1985). In their study of secondary school students' mathematics self-efficacy in a problem-solving context, Pajares and Kranzler (1995) used path analysis to identify a direct effect of self-efficacy on performance (β = .35). Stevens (2009) described mathematics self-efficacy as mediating the effect of ability on achievement. Other studies in contexts as diverse as musical performance anxiety (Kendrick, Craig, Lawson, & Davidson, 1982) and smoking cessation (Mermelstein, Lichtenstein, & McIntyre, 1983) have found that self-efficacy is a better predictor of behaviour than is past performance. In an education setting, the relationship between self-efficacy and achievement is thought to be reciprocal (Bandura, 1986; Schunk, 2008) (see *Past performances*, earlier in this chapter).

Looking beyond primary school, mathematics self-efficacy has also been found to be associated with US students' intentions to enrol in future mathematics courses at high school (Stevens, Wang, Olivárez, & Hamman, 2007) and college (Lent, Lopez, & Bieschke, 1993). Hackett and Betz's (1984) study identified gender differences in career choices that were associated more strongly with perceived mathematics self-efficacy than with actual mathematics achievement, with young women more likely than men to avoid careers that necessitated using aspects of mathematics.

Trends in mathematics self-efficacy

The identification of trends in data is important in explaining and understanding a phenomenon. Data from empirical studies that have gauged mathematics self-efficacy of students of primary school and beyond have been used to identify trends associated with students' age and gender, both of which were investigated in the present study. Although a number of empirical studies have investigated relationships between self-efficacy and ethnicity, this literature is not included here because examining differences associated with ethnicity was not an aim of the present study.

Students' age

There is disagreement about the way self-efficacy develops over the primary school years. On the one hand, Zimmerman and Martinez-Pons (1990) found an increase in mathematics self-efficacy from fifth to eighth grades. On the other hand, some assessments of primary students' mathematics self-efficacy have indicated that it tends to decline with age (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Frey & Ruble, 1987), although in addition to maturation this change might also be due to the increasing difficulty of mathematics tasks as students progress through school, and accumulated environmental effects of the school system (for example, ability-based grouping and the type of teacher-student feedback). As students' cognitive skills develop during primary school, they are thought to develop more accurate self-appraisal skills (Nicholls & Miller, 1984). However, the studies cited above were all cross-sectional in nature; a lack of longitudinal studies makes it difficult to know what the typical trajectory of primary students' mathematics self-efficacy over time might in fact be.

According to Pajares (1996a), students' self-efficacy tends to be high in the early primary school years, and at this age students often over-estimate their capabilities. He suggested that when a student's self-efficacy is just slightly over-estimated, it should result in their increased effort and perseverance at a task, thereby positively influencing their performance. Bandura (1997) also maintained that the ideal is for a student's self-efficacy beliefs to be slightly beyond their actual skill level. However, it is not helpful for a student's learning when their self-efficacy for completing a particular task goes well beyond their actual skill level, because they are unlikely to seek the help they probably need to successfully complete the work**.**

Students' self-efficacy has been found to slip at transition points, such as the shift from primary to intermediate schools (Eccles & Midgley, 1989). This is thought to be related to the many associated changes. For example, instead of spending their whole day with the same teacher, students are likely to rotate around several teachers with the result that their relationships with teachers may not be as close as those they had during primary school. Additionally, they will probably have their peer networks disrupted by re-grouping of students across classes. Teaching is likely to be less focussed on the concrete experiential learning that is generally a hallmark of the primary years, and instead to introduce content of a more abstract nature, in line with typical developmental stages.

More measurement of mathematics self-efficacy has focused on the self-efficacy of intermediate and secondary school students than those at primary school. A significant body of research has investigated aspects of the relationship between mathematics self-efficacy and outcomes at secondary and tertiary levels (for example, Pajares & Kranzler, 1995; Pajares & Miller, 1994; Zimmerman, Bandura, & Martinez-Pons, 1992), using a mixture of task-specific and domain-specific self-efficacy measures. What the majority of these studies have in common is that they aimed to establish relationships between self-efficacy and other constructs, such as interest or achievement, and generally involved one-off, self-report measures of self-efficacy.

To reliably identify how mathematics self-efficacy might change with age, longitudinal studies are necessary rather than piecing together results from studies with participants of different ages, in a jigsaw-like fashion. Two longitudinal studies of primary students' mathematics self-efficacy (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006; Liew, McTigue, Barrois, & Hughes, 2008) have taken non-task-

specific interpretations of mathematics self-efficacy. For instance, Kenney-Benson et al. (2006) asked 10 to 13-year-olds to respond to statements such as, “I can do even the hardest maths work in my class if I try” (p. 16), and Liew et al. (2008) asked 6 to 9-year-old students whether they were “good at numbers” and “good at adding” (p. 518).

One longitudinal study of primary students’ mathematics self-efficacy (Pajares & Graham, 1999) operationalised self-efficacy in a task-specific manner. The mathematics self-efficacy of 11 to 12-year-olds in their first year at a middle school in the US was assessed on two occasions, 6 months apart, using two different exams. The data showed similar moderate positive correlations between the 273 students’ mathematics self-efficacy and achievement on both occasions. A decrease in mean self-efficacy at the second data collection point was attributed by the researchers to the more difficult exam content. However, using two different achievement measures that were not calibrated for difficulty makes drawing reliable conclusions problematic.

Students’ gender

A subset of mathematics self-efficacy research has examined the specific relationship between gender and mathematics self-efficacy, with mixed results. In Schunk and Hanson’s (1985) experimental study of the influence of peer models on 8 to 10-year-olds’ subtraction learning, no significant gender differences in mathematics self-efficacy or achievement were identified. Neither were gender differences in self-efficacy or achievement found among the Norwegian Grade 6 students in Skaalvik’s (1990) study. Soon after that, however, a comparison of the mathematics self-efficacy and achievement of gifted and average ability 10 to 11-year-olds in the US found boys had higher self-efficacy ratings, irrespective of ability, and that boys tended to over-estimate more than girls did (Ewers & Wood, 1993). This study did not identify any differences in the achievement of girls and boys. Gender differences in self-efficacy for different school subjects were identified by Eccles et al. (1993) who found that boys in Grades 1, 2, and 4 had higher self-efficacy for mathematics and sport, while girls’ self-efficacy was higher for reading and music, perhaps reflecting gender stereotypes at that time. No measure of students’ achievement was included in Eccles et al.’s study. More recently, Lloyd et al. (2005) identified that the Grade 4 and 7 girls in their study tended to have higher achievement than boys, although their mathematics self-efficacy was lower than

boys'. The different results in this small collection of studies involving primary school students might reflect a gender difference emerging over the years, with cultural differences another possible contributor to the studies' disparate results. Moreover, different self-efficacy measures were used in each study, making it difficult to draw comparisons.

Interventions to raise students' mathematics self-efficacy

Since Bandura's early work on self-efficacy, there has been a wealth of studies that seek to describe and explain self-efficacy and its role in student achievement, but fewer that have also explored the effects of interventions. Intervention studies have an independent variable that is manipulated by the researcher to identify the effects this has on a dependent variable. Experimental studies include the additional condition of random assignment of participants to treatment groups. From the data generated by studies that investigated the effects of such manipulations, associations can generally be reasonably inferred. However, in a systematic review of non-intervention studies that were published in 1994 and 2004, Robinson, Levin, Thomas, Pituch, and Vaughn (2007) noted that an increasing number of authors of descriptive studies have been making unfounded claims about causality and from these, prescriptive statements.

Internationally there is still a relatively small body of research into the effects of self-efficacy interventions with primary students. Schunk and his colleagues (Bandura & Schunk, 1981; Schunk, 1981, 1982, 1983a, 1983b, 1983c, 1985, 1996; Schunk & Gunn, 1985, 1986; Schunk & Hanson, 1985, Schunk et al., 1987), however, have contributed much in this area, conducting a variety of experimental studies that identified associations between increases in the mathematics self-efficacy and achievement of primary students – typically, students who struggled in the target learning area. From these studies, strategies to help build self-efficacy have been suggested, such as using similar peers as models rather than teacher models, and providing students with clear proximal learning goals. More recently, Farkota (2003) demonstrated positive effects on Year 7 students' mathematics self-efficacy of a direct-instruction intervention designed to increase students' academic skill levels. The intervention also increased students' mathematics self-efficacy levels during their first year at secondary school in Australia – a transition period for students that often has negative effects on achievement and self-efficacy.

Few interventions have involved teachers implementing strategies aimed at directly building students' mathematics self-efficacy in classroom settings; more commonly, students were withdrawn from the classroom to work one-to-one with a researcher (for example, Ramdass & Zimmerman, 2008). In addition, reported interventions have tended to be short in duration, with no follow-up assessment to identify enduring or delayed effects, impacting on the strength of their findings.

One recent, American study (Siegle & McCoach, 2007) included a four-week intervention, and showed that the 10 to 11-year-old participants reported increased self-efficacy for measurement tasks after a unit on measurement, during which their teachers modified their instructional strategies to include:

- Sharing learning intentions with the students at the beginning of the lesson, making connections to these during the lesson, and revisiting their progress towards these at the end;
- Supporting students to attribute poor performances to lack of effort (rather than lack of ability);
- Highlighting students' progress, and praising their skill development;
- Having students keep a record of their learning;
- Using peer models (rather than teacher models) wherever possible, to help students see that they can master the material.

Siegle and McCoach's (2007) study did not result in clear achievement gains for the students in the treatment group over and above those of the control group. They surmised this may have been because students were given insufficient opportunities to apply their increased effort and persistence, as the 4-week measurement topic comprised a number of sub-topics for which students had only one or two instructional sessions. As no follow-up data were collected, it is not known if students' increased self-efficacy levels endured and whether this might have had a delayed effect on their achievement. From the study's description it is unclear whether the mathematics self-efficacy items were measurement task specific, or related to measurement in general.

In their meta-analysis of the relationships between self-efficacy, academic performance, and persistence, Multon, Brown, and Lent (1991) suggested that self-efficacy interventions may be of greatest benefit to low-achieving students. Furthermore, they supported such work with primary students:

> Perhaps a by-product of such interventions is that they accelerate the accuracy of self-appraisal processes that improves naturally over time. At any rate, given the potential value of primary prevention programs for school achievement problems … further research on self-efficacy-based interventions for younger students seems warranted. (p. 35)

It has been suggested that by identifying a student's perceived self-efficacy early in their education, teachers can compare this information to the student's achievement data to help identify any disparity, and plan interventions to work towards their closer alignment, or to improve both, as appropriate (Pajares & Miller, 1994). However, as Bandura (1977a) pointed out, because individual students have each had their own collection of efficacy-influencing experiences, each will interpret in their own way any new source of efficacy information so that changes in self-efficacy across a class, following an intervention, will not be uniform.

The lack of mixed-methods designs in mathematics self-efficacy studies

Because self-efficacy research comes from the psychology tradition, one of the striking features of the mathematics self-efficacy empirical studies is the dominance of quantitative methods. Indeed, only three mixed-methods studies of mathematics self-efficacy were located, one of which related to college students (Goodykoontz, 2008), and the second, to teachers' mathematics self-efficacy (Kahle, 2008). The third instance, Meyer et al.'s (1997) study, prioritised their qualitative data from interviews conducted before, during, and after project-based mathematics instruction, with 14 students. Quantitative data comprised students' achievement information and their responses to a survey in which their self-efficacy was measured by items that were not problem specific, such as "I can do almost any problem if I keep working at it" (p. 507). Results from the quantitative data from such a small sample should be interpreted with caution.

In the overwhelming majority of studies of primary students' mathematics self-efficacy, quantitative measures of mathematics self-efficacy and achievement are included, often with measures of other variables such as students' goal orientation or teachers' perceptions of students' abilities. The current knowledge has been built on a strongly quantitative foundation. Adding qualitative data that examine what underpins students' (and teachers') reported self-efficacy beliefs, could extend this knowledge.

Chapter summary

The theoretical perspectives and relevant empirical evidence that underscore the importance of strengthening students' mathematics self-efficacy have been discussed. One central issue relating to existing studies of primary students' mathematics self-efficacy is the persistent inconsistencies in interpretation and assessment of self-efficacy that preclude any meaningful discussion of the collective findings of self-efficacy studies. Self-efficacy is sometimes operationalised at a domain-related level and confused with self-concept, and at other times is interpreted at a task-specific level, as originally intended by Bandura. Typically, assessments have not included a consideration of the specific difficulty levels of mathematics problems about which self-efficacy judgments are made. A tendency to use data analysis methods developed for use with interval data, with data that are ordinal in nature, was evident in the research literature.

A second issue is the paucity of longitudinal and mixed-methods studies to build a reliable picture of how students' mathematics self-efficacy changes over time, and how this might be associated with developments in achievement. Furthermore, past interventions in this area have generally been very short, with intervention effects assessed immediately afterwards rather than investigating the enduring effects – if any – of the short-term changes reported.

CHAPTER 3
Students' Beliefs about Intelligence

A working definition of *intelligence*

The assumption that everyone shares a common definition of *intelligence* is made even by researchers who seek to investigate differences in people's beliefs about intelligence. The term *intelligence* has been used by various researchers to mean different things, although their conceptualisations of intelligence have not been explicitly stated. Furthermore, *ability* and *intelligence* have often been used synonymously by researchers in education contexts.

In this thesis, intelligence is conceptualised as comprising three dimensions: one, the complexity of knowledge and skill that can be learned in a given domain; two, the capacity for such learning; and three, the rate at which such knowledge and skill can be acquired. This working definition is compatible with Gardner's (1983) multiple intelligences, and with the knowledge acquisition component of Sternberg's (1985a) triarchic theory of intelligence, from which it was developed.

Theoretical background

Sternberg (1985b) explained that psychologists had been unable to agree on a definition of intelligence (or definitions for two other psychological constructs, creativity and wisdom). This lack of definition, he pointed out, made the development of explicit theories about intelligence difficult. In lieu of explicit theories of intelligence, he suggested that implicit theories – "constructions by people … that reside in the minds of these individuals" (p. 608) – could provide a useful conceptual framework from which explicit theories might then be developed. Sternberg described the purpose of eliciting people's implicit theories of intelligence (and other psychological constructs) as being to learn more about the nature of the construct under investigation.

That same year, Sternberg (1985a) tackled the issue of defining intelligence, and proposed his (explicit) triarchic theory of intelligence which comprised three sub-theories: creative intelligence, contextual intelligence, and analytical intelligence. In his broad conceptualisation of intelligence, creative intelligence is concerned with the way in which an individual responds to novel situations, and how he or she thinks innovatively to solve problems. Contextual intelligence relates to the way in

which individuals understand, adapt to, and shape their environments, and how they deal with everyday tasks. Analytical intelligence is responsible for analysis and critical evaluation, and resembles psychometric definitions of intelligence as measured by academic problem solving.

Analytical intelligence was, in turn, conceptualised by Sternberg as being multi-dimensional, comprising three components concerned with information-processing: meta-components, the higher-order processes responsible for controlling and monitoring cognitive functioning such as analysing a complex mathematics problem and choosing a strategy to solve it; performance components, the basic operations of cognitive processing, such as actually performing mental calculations or retrieving information from long-term memory; and knowledge acquisition components, the lower-order processes used for gaining new knowledge and developing new skills, for example, strategies for memorising basic facts. Researchers working in education contexts who have investigated students' beliefs about intelligence in academic settings seem to have adopted a knowledge-acquisition interpretation of intelligence, focussing on an individual's capacity for learning.

A few years after the publication of Sternberg's (1985a) triarchic theory of intelligence, Dweck and Leggett (1988) aligned their research to a social cognitive model in order to help explain students' behaviour – in this case, students' achievement. Based on a collection of Dweck and associates' studies, they proposed a model positing that students' achievement is influenced by their implicit theory of intelligence, and by the types of goals to which their theories of intelligence would predispose them. They conceptualised both theory of intelligence and learning goals as personal factors. Dweck and Leggett's (1988) model built on an earlier publication in which the effects of theory of intelligence had first been hypothesised (Dweck & Bempechat, 1983). The central tenet of the 1988 model was that individuals have one of two implicit theory of intelligence beliefs: an incremental belief that they can increase their intelligence; or an entity belief that their intelligence is stable and unalterable. According to Dweck and Leggett's theory, a student who believes intelligence is fixed has an entity theory of intelligence, and is likely to choose performance goals that will lead to positive judgments for good performance. These students will avoid negative ability judgments by avoiding challenges that might result in failure, according to the theory. In contrast, an incremental theorist believes intelligence can be increased,

and according to Dweck and Leggett, their goals are likely to focus on learning, so that they seek challenges, persist when these prove difficult, and are not as worried about consistently performing well. Under the theory, incremental theorists accept that making mistakes is associated with the learning process, and are not deterred by this. The underlying implication in studies of implicit theory of intelligence has been that having an incremental theory has positive effects, and an entity belief, negative effects, on students' achievement. Since proposing this model in 1988, Dweck and colleagues have conducted a number of studies in which students' achievement and their beliefs about the malleability of intelligence have been measured. Associations between implicit theory of intelligence and achievement, and ways theory of intelligence has been manipulated in intervention studies, are of particular interest for their potential to raise student achievement.

The lack of definitions of *intelligence* in the research literature

Dweck and her colleagues conducted a number of studies of what they termed *implicit theory of intelligence* over several decades (for example, Blackwell et al., 2007; Dweck & Bempechat, 1983; Dweck, Chiu, & Hong, 1995) with participants ranging in age from pre-schoolers to adults. In each of these studies, the researchers shied away from providing a working definition of how they interpreted the term *intelligence*. The lack of a definition of intelligence over a fairly extensive programme of research is one of a number of reasons that the work of Dweck and colleagues has been examined here with a somewhat sceptical eye, and is also why some of Dweck's research methods were tested in the present study. I will refer to a person's belief about the malleability of intelligence as their *theory-of-intelligence*, to differentiate this implicit theory or belief, from the explicit theories described elsewhere in this thesis.

The synonymous use of *intelligence* and *ability* pervades the research literature (for example, Cain & Dweck, 1995; Law, 2009; Mueller & Dweck, 1998; Pepi, Alesi, & Rappo, 2008; Pomerantz & Ruble, 1997; Stipek & Gralinski, 1996), with considerable overlap in the ways intelligence and ability have been interpreted by researchers. Just as no definition was furnished for *intelligence*, so is *ability* typically left undefined. Both terms appear to be used to mean *a capacity for learning*. The studies that are scrutinised in this chapter therefore include those that have investigated primary students' beliefs about both intelligence and ability where they appear to be interpreted as a capacity for learning.

Dweck and Leggett (1988) used *intelligence* interchangeably with *ability*, defining a student's theory-of-intelligence as "their implicit conception about the nature of ability" (p. 262). Furthermore, Dweck and Leggett did not define *intelligence*, and in her more recent work, Dweck (2000) has continued to avoid doing so, "for there is no agreed-upon answer" (p. 60). Although Cain and Dweck (1989) did not give their own definition of intelligence, they hypothesised a model of intelligence comprising a stable capacity and a knowledge component that can be increased through effort. They surmised that people's definitions of intelligence include both components, and that whether someone was an entity or incremental theorist was determined by whether they focussed more on the stable capacity component or the malleable knowledge component. However, no published report of any empirical study that tested their theorised model could be located. It seems possible that the stable capacity in their model might have been consistent with the meta-components and performance components of analytical intelligence in Sternberg's (1985a) triarchic theory, and their knowledge component similar to Sternberg's knowledge acquisition, but these links were not made by the researchers, and neither were they empirically tested. A subsequent study by Mueller and Dweck (1998) included students' definitions of intelligence; the problems with that study are outlined shortly.

The development of students' conceptions of *intelligence* and *ability*

Very few studies have actually investigated students' ideas about what *intelligence* is, or in the case of young children, what being *smart* might mean to them. As an indication of the paucity of research in this area, Kinlaw and Kurtz-Costes (2003) reviewed research related to children's definitions of intelligence, and summarised findings from three published studies, published around 10 years apart, showing how little attention this question has received. In one of the studies reviewed – Yussen and Kane's (1985) cross-sectional study – 71 first, third, and fifth graders were interviewed for their ideas about intelligence: its malleability, the influences of environment and heredity, visible signs of intelligence, and children's definitions of intelligence. Students were from 6 to 12 years old, and the researchers used the words *intelligent* and *smart* interchangeably. For example, each child was asked "What does it mean to say someone is *smart"* and then "What does it mean to someone is *intelligent*?" (p. 238). Children's verbal ability was measured to give an indication of their level of intellectual functioning.

Eleven categories of definition were developed from children's definitions: *knowledge*, *thinking*, *problem solving*, *academic skills*, *social skills*, *arrogance* (someone who thinks they know everything), *being good at something*, *same* (for children who said that being *intelligent* was the same as being *smart*, when asked the second definition question), *miscellaneous*, *clever*, and *experiences* (a person had had more and perhaps better experiences). How the researchers differentiated a definition that they classified as *being good at something* from another classified as *clever* is uncertain. To report children's definitions of intelligence, Yussen and Kane presented the percentage of the total number of definitions provided by children in each year group that were given each classification. They found that younger students (6 to 7-year-olds) tended to include social skills in their definitions more than older children, who instead focussed more on academic skills. Yussen and Kane suggested that this difference might be associated with the teaching foci at different stages of schooling. The inclusion of knowledge was greatest among the first graders, but did not decrease significantly for the older children. Almost half of the sixth-grade children indicated that *intelligence* meant the same to them as *smart*, although no first graders suggested this.

Children in Yussen and Kane's study were also asked five questions relating to the malleability of intelligence, including whether a person could increase or decrease their intelligence. The items did not ask children for their beliefs about their own intelligence, instead referring to people more generally. For example, they were asked, "If someone is (smart/intelligent) as a child, can he/she be not so (smart/intelligent) when he/she grows up?" (p. 240). At all grades, particularly first grade, children were more likely to agree that intelligence can increase than they were to agree that it can decrease. Although no direct links were drawn between children's definitions of intelligence and their beliefs about how a person's intelligence could change, it seems likely that if young children include social skills in their definitions of intelligence, then they are perhaps more likely to be optimistic about people's intelligence increasing, than older children whose definitions focussed on academic skills.

Cain and Dweck's (1995) mixed-methods study, also reviewed by Kinlaw and Kurtz-Costes, included 139 students (6 to 11-year-olds) being asked "'Do you know what the word 'smart' means? What does it mean to say someone is smart in school?'" (p. 34). Students' responses were classified as either: outcomes (for example, a student who gets most things right); processes, such as effort or learning-related

behaviours (like paying attention); ability, which Cain and Dweck described as "references to enduring knowledge or talent" (p. 41); external factors, such as help from their parents; and "other". The first two of these categories – outcomes and processes – were set by the researchers, based on Dweck and Leggett's (1988) model that hypothesised that entity theorists would have outcomes-focused definitions of intelligence, and incremental theorists would have process-focussed definitions. The three remaining categories were developed from students' responses that did not fit these two categories. To quantitise[5] the resulting categorical data, "For each child, the number of units in each category was summed and then converted to a proportion of the total units in the child's answer" (Cain & Dweck, 1995, p. 41), where a unit was any part of a response that matched one of the five categories. Means for each category by grade level were then calculated. Using these quantitative analytic methods on what was originally qualitative data is dubious at best, so the findings of this study should be interpreted with caution.

Focusing on students' definitions that had been coded as outcomes and processes, Cain and Dweck identified no significant differences according to students' year level, and reported that "The most frequent criterion of intelligence was ability" (p. 45) – something of a tautology due to the synonymous way in which they have used *intelligence* and *ability* in their writing. One perhaps unsurprising difference that they highlighted was that younger students were more likely than older students to be unable to give a definition of *smart*. For students who were able to define *smart*, Cain and Dweck identified no developmental differences. Given the age range of their participants (7 to almost 11 years old), and the findings of other studies (for example, Kurtz-Costes, McCall, Kinlaw, Wiesen, & Joyner, 2005; Yussen & Kane, 1985), this finding is perhaps reflective of their specious data-analysis methods.

Students' theory-of-intelligence was also measured, using three entity-belief items:

- You're a certain amount smart and you really can't do much to change it;
- How smart you are is something about you that you can't change very much; and
- You can learn new things, but you can't change how smart you really are. (Cain & Dweck, 1995, p. 34)

[5] In the mixed-methods literature, "quantitise" is used to mean the numerical translation of qualitative data (Sandelowski, Voils, & Knafl, 2009; Teddlie & Tashakkori, 2006).

Each item was read to the child, who was then asked, “Does this sound right to you?” (p. 34). After their “yes” or “no” response (no other response was accounted for), the child was then shown a 3-point scale ranging from “That sounds really right” to “That sounds a little bit right” (p. 34) (with a parallel version for a negative response). This 2-step process yielded a 1 to 6 score for each item, with 6 signifying a strong entity belief. However, the ordinal data from each student’s scores for the three items were then inappropriately treated as interval data and averaged, before an analysis of variance was conducted, again casting doubt on their findings.

The final study of children’s beliefs about intelligence included in Kinlaw and Kurtz-Costes’ (2003) review, was Kurtz-Costes et al.’s study, subsequently published in 2005. They interviewed 100 students in Germany and 115 in the US, from 5 to 14 years old, and asked them nine questions about being smart, including “What does it mean to be smart?” and “How do you know if someone is smart?” (p. 222). From a pilot with 20 children, the researchers established response categories of: “knowledge/achievement”; “effort”; “good citizen” (p. 222; for example, following directions, being well-behaved); and “other”. Their findings indicated that definitions most frequently included knowledge or achievement, and that the youngest children in the study were less likely than the older children to mention these. Younger students were more likely to give responses that were classified as “good citizen” or “other”, although almost no discussion of this was included. The older children tended to relate being smart to cognitive abilities, with the role of effort mentioned less by older than by younger participants. No significant difference between students from the two countries was evident.

In the same study, a single question was used to determine participants’ theory-of-intelligence: “If you’re not very smart, can you change to get smarter?” (p. 226). “Maybe” and “Yes” responses were collapsed into a single category which was then compared to “No” responses. Treating the theory-of-intelligence data this way, they found that German students tended to have an entity belief more than US students, and that older students in both countries were more likely than younger students to have an entity theory-of-intelligence. However, this is based on data from one item, and on classifying “Maybe” (or maybe not) as an affirmative response, making the findings less than robust.

In their review of what was known about children’s judgments of their intellectual competence and their thinking about ability, Stipek and MacIver (1989) pointed out

that, particularly during the first year of school, teachers tend to focus on establishing appropriate social behaviour and work habits, and on reinforcing the value of effort. It seems likely that younger students might perceive these behaviours as contributing to being smart or intelligent in a school context, which could account for the young children in Kurtz-Costes et al.'s (2005) study giving more responses than older participants that were classified as "effort", "good citizen" or "other".

Students' definitions of intelligence have been the focus of only a small number of studies, so the means used to identify their beliefs have been limited to asking them directly what they think it means to be intelligent or smart (Cain & Dweck, 1995; Kurtz-Costes et al., 2005; Yussen & Kane, 1985) in one-to-one interview situations. In the first two of these studies, students' responses have been coded according to *a priori* categories, with additional categories developed from the data as appropriate. Cain and Dweck (1995) and Kurtz-Costes et al. (2005) included both a measure of theory-of-intelligence and students' definitions of intelligence, but their doubtful data analysis methods make their findings unconvincing.

Although primary students' definitions of intelligence have been explored in terms of the relationship between ability and effort, whether the capacity for, and rate of, knowledge acquisition is included in their beliefs does not appear to have been investigated with this younger age group. Adults' beliefs about the rate of knowledge acquisition, on the other hand, have been examined. For example, Braten and Stromso (2004) investigated 80 Norwegian student teachers' (mean age 24.4 years) epistemological beliefs about the rate of knowledge acquisition, as well as their theory-of-intelligence, and how both of these were related to their achievement goals. Measures of epistemological beliefs, theory-of-intelligence (using Dweck's items), and goal orientation were taken at the start of the study, and the goal orientation measure was repeated a year later. Their findings indicated that some student teachers' beliefs that learning occurred either quickly or not at all were associated with these students being less likely to adopt mastery goals than those who believed learning occurred over time. A regression analysis showed theory-of-intelligence was not a significant predictor of mastery goal orientations at both Times 1 and 2, contrary to models proposed by Dweck and colleagues (Dweck et al., 1995; Dweck & Leggett, 1988). Beliefs about knowledge were stronger predictors than was theory-of-intelligence. Defining knowledge as a stable capacity was a significant moderate negative predictor of mastery goals at Time 1

(β = -.38, p < .01), but was no longer significant at Time 2. Speed of knowledge acquisition was also a negative predictor of mastery goals at Time 1 (β = -.32, p < .01), and at Time 2 (β = -.26, p < .05), indicating that mastery goals were less likely to be adopted by students who believed that learning occurred quickly. In their discussion of the disparity between their findings and those described by Dweck (2000), Braten and Stromso (2004) made the point that much of Dweck's research has been conducted in laboratory-like conditions, rather than being field research like their study. More importantly though, the authors highlighted that these student teachers studied in "an innovative, co-operative instructional context" (p. 371), so their orientations towards grades and achievement are likely to have differed to those of students who have participated in studies in the US.

In another experimental study, Mueller and Dweck (1998) investigated the effects of praise for ability and effort on students' motivation, including the effects of praise on students' theory-of-intelligence and on their definitions of intelligence. Forty-eight fifth-grade students (mean age 10.8 years) were randomly divided into three treatment groups. Students were presented with three sets of 10 mathematics problems, each of which they were allowed 4 minutes to work on. The second set of problems was intended to prove more difficult for the students than the other two sets of problems. Regardless of students' actual performance, all of them were told that they had performed poorly on the second set of problems. (At the conclusion of each interview, students were told that this set of problems was difficult because they were intended for older students.) After each set of problems, students were given one of three types of praise: praise for their ability; praise for their effort; or praise with no attribution. Experimenters then administered a collection of motivation-related measures, including one of students' theory-of-intelligence that required them to rate how much they agreed with the single statement, "You have a certain amount of intelligence and really can't do much to change it" (p. 44). Students were also asked to complete the sentence "I think intelligence is…". The definitions of intelligence that students gave were then coded using two *a priori* categories: "their use of terms that emphasized the more malleable or motivational components of intelligence (e.g., effort and knowledge) and their use of terms that emphasized the trait-like nature of intelligence (e.g., ability and smartness)" (p. 47). A chi-squared test indicated a significant difference between the number of students who had been praised for their effort who included effort in their definitions of intelligence, and the number who were praised for their ability who mentioned

effort. No significant differences were detected among the three treatments with regard to their use of trait-like definitions of intelligence. Nonetheless, Mueller and Dweck (1998) reported:

> Children praised for ability after good performance were found to be somewhat more likely to later describe intelligence as a trait and to see it as not being subject to improvement than were children praised for effort, who preferred to define it in malleable or motivational terms and to view it as something that is subject to development or improvement. (p. 48)

There are several points to make about this study. First of all, like most of Dweck's other studies, it was conducted in a laboratory-like situation. Secondly, the researchers were interested in the effect of particular types of praise on students' thoughts about the malleability of intelligence, and their definitions of intelligence. However, these measures were not taken for the same, relatively-small sample (16 in each treatment) pre-intervention, so the causal links suggested in the quote above cannot be reasonably substantiated. Thirdly, the two categories that were imposed on students' definitions were clearly designed to match the *ability* and *effort* categories of praise, rather than being theoretically derived in their own right. No information was presented regarding the frequencies with which students' definitions matched these two categories, or if any students' definitions might have matched neither category. Finally, using a single item to measure theory-of-intelligence seems to be another short-coming of the study.

A number of studies have explored students' ideas about the relationship between *ability* and *effort*. Key among studies of ability is Nicholls' (1978) investigation of students' ideas about the relative roles of ability and effort. In a cross-sectional study, 162 students' (5 to 13-year-olds) concepts of effort and ability were examined. Nicholls conceptualised ability and effort as being inter-dependent: "Ability refers to what a person can do, and evidence of optimum effort is required before we accept performance as indicative of ability. This concept of ability implies that ability limits the extent to which effort can increase performance" (p. 800). Participants were each shown three 90-second silent films of two students working on problems from a mathematics textbook. In each film, one student was engaged in their work for the whole time and the second student divided their time between working and what might be considered off-task behaviours – fiddling with their pencil and textbook, or gazing around the room, for example. Prior to viewing the films, students were told that both students in the first film answered 10 out of 10 problems correctly; in the second film, both answered two problems correctly; and

in the third film, the student who at times showed off-task behaviour scored eight out of ten, and the student who worked consistently scored just two. Students were primed to think about ability and effort by asking them to think about whether one student in the film worked harder, and whether one is smarter than the other. Similar questions were asked after the student had watched each film, as well as asking "How come they got the same when one worked hard and one didn't work hard?", and "If they both worked really hard would one get more than the other or not?". In relation to the third film, students were asked "How come the one who didn't work hard got more than the other one?" (p. 803).

From students' responses, Nicholls (1978) identified approximate age bands during which progressively more advanced reasoning about ability and effort were evident. The four levels of reasoning were:

- Level 1: Neither effort nor ability are yet identified as related to outcome (approximately 5 to 6 years old);
- Level 2: Effort and outcome are identified as cause and effect. Ability is not yet perceived as a cause of outcomes (approximately 7 to 8 years old);
- Level 3: Effort is no longer perceived as the sole cause of outcomes, with ability sometimes related to outcomes (approximately 8 to 9 years old);
- Level 4: "The concept of ability, in the sense of capacity which, if low, may limit or, if high, may increase the effectiveness of effort, is used systematically" (p. 812) (approximately 9 to 10 years old).

More recently, a larger cross-sectional study (Malmberg, Wanner, & Little, 2008) investigated school-type and age differences in the beliefs of 1,723 students in Berlin by taking one-off measures of their beliefs about ability, effort, and task difficulty. Their findings showed that the younger students of their 10 to 16-year-old cohort did not differentiate ability and effort as clearly as the older students did, suggesting that there is further development of students' thinking about the ability/effort relationship beyond Nicholls' (1978) fourth level. Students' cognitive development would obviously play a role in determining their responses to questions about how they perceive ability and effort, as would the socio-political value system to which they are exposed.

In the same year, Heyman (2008) conducted three related studies of the effects on 8 to 12-year-olds of experimenters describing the successful performance of other students as either ability related or effort related. Students were read a series of scenarios that described fictitious students' achievement, for example, "Nicholas does very well in school. He did very well even when he was little" (p. 366). This was

followed with questions, such as “Does Nicholas do well in school now because of the kind of brain he was born with?” and “Will Nicholas do well in school when he is older even if he doesn’t try very hard?” (p. 366). Students’ “no”, “maybe”, and “yes” responses were coded as 0, 0.5, and 1, respectively, and analyses of variance were conducted – once again, with ordinal data. However, what was interesting in Heyman’s study was her suggestion that presenting students with descriptions of high-achieving students who had struggled to overcome academic difficulties seemed to make participants more optimistic about overcoming their own difficulties through applying effort. On the other hand, the findings indicated that using ability-related labels, such as “maths whiz”, resulted in students being more inclined to attribute that person’s success to innate ability. Heyman proposed that teachers should provide students with information that can help them to understand their successes and failures in terms of effort. Rather than giving students messages that they might interpret as ability being an innate quality, messages that highlight success following a sustained period of difficulty seem likely to make students more willing to work through the difficult learning they encounter. The implication that the importance of effort should be underscored is consistent with Stipek and Gralinski’s (1996) recommendation:

> …that if our goal is to decrease students’ concerns about performance, we may need to focus our efforts on changing their general beliefs about intelligence (i.e., the degree to which it is fixed and stable and affects performance). If our goal is to increase their mastery goals, we may need to convince them of the value of effort (p. 405).

Students’ beliefs about the malleability of intelligence

For purposes of succinctness, theory-of-intelligence will be discussed here – as it is elsewhere – using the dichotomous terms of incremental and entity theories. The research literature in this area is characterised by discussions of whether or not students believe they can increase their intelligence, and has not included data about how much students believe they can increase their intelligence, and why they believe this.

Exactly what has been measured?

Unlike self-efficacy, beliefs about the malleability of intelligence have not been supported by strong theoretical underpinnings. Furthermore, it is difficult to be sure of what has actually been measured in the empirical studies, due to a paucity of reports of rigorous statistical analysis of theory-of-intelligence items in the literature.

Theory-of-intelligence has been interpreted in two main ways: as a global belief, and as a domain-specific belief relating to ability in mathematics (and other school subjects). In a review of research that investigated how people's global beliefs about intelligence affected their judgments and reactions, Dweck et al. (1995) reported a factor analysis for the three extremely similar entity-belief items (the first three items in Table 3.1) that found they loaded heavily on the same factor, with loadings in the .93 to .95 range. Dweck et al. analysed the data from five validation studies involving adults and found that this factor was distinct from the two other target factors – malleability of moral character and malleability of the world (assessed with items such as, "Though we can change some phenomena, it is unlikely that we can alter the core dispositions of our world", p. 271). No other factors relating to motivation were included in this analysis. No report of a factor analysis for the last three items in Table 3.1 – the incremental-belief items (Dweck, 2000) – could be found, suggesting that they have not undergone the same testing as the entity items. Although the near-identical nature of the six items in question suggests that they should probably load on the same factor, no evidence has been reported to confirm or refute this.

Table 3.1: Dweck's (2000, p. 177) theory-of-intelligence items

The first three entity-belief items were originally in Dweck, Chiu, and Hong (1995, p. 271), and subsequently included in Dweck (2000), together with the incremental-belief items 4 to 6.

1.	You have a certain amount of intelligence, and you really can't do much to change it.
2.	Your intelligence is something about you that you can't change very much.
3.	You can learn new things, but you can't really change your basic intelligence.
4.	No matter who you are, you can change your intelligence a lot.
5.	You can always greatly change how intelligent you are.
6.	No matter how much intelligence you have, you can always change it quite a bit

Stipek and Gralinski (1996) investigated whether theory-of-intelligence was domain specific by comparing students' beliefs about the malleability of their ability in the dual contexts of mathematics and social studies. At the start and end of a school year, 319 students in third to sixth grade completed a questionnaire, making responses on a Likert-type scale. Their grades for mathematics and social studies were also collected. Stipek and Gralinski reported a factor analysis of their 12 items that showed two factors with eigenvalues greater than 1.0, at both time points. Because both sets of data were fairly similar, only the start-of-year analysis is described here. Eight items had loadings of .51 to .69 on the first factor, labelled "entity-related beliefs". Three of these items appeared first in the questionnaire, and included a reference to effort. For example, the first item was "Some kids can never do well in math, even if they try hard" (p. 400). These three items may have had the effect of priming students to think about both effort and being smart when they then responded to five items about being smart, such as "You have to be smart to do well in social studies". Loadings on the first three items were .66 to .69, while on the next five items loadings were smaller, ranging from .51 to .58. Because loadings under .45 were omitted, it is not known whether some items may have had moderate cross-loadings on the other factor. Whether it was reasonable to interpret this factor as "entity-related beliefs" seems questionable, and in fact, Stipek and Gralinski later describe this factor as ability-performance beliefs.

The second factor represented students' beliefs about effort. The four items associated with this factor, such as "Everyone could do well in math if they worked hard" (p. 400), had loadings of .47 to .67. Items related to mathematics and social studies loaded similarly on the same factors, suggesting that students' beliefs for each domain were not differentiated. Stipek and Gralinski created two sub-scales to use in their subsequent data analysis – ability-performance beliefs and effort-related beliefs – which were applied to mathematics and social studies items alike. They found no significant correlation between the two sub-scales beyond the third grade, suggesting that by the age of nine or ten, at which children are thought to have developed an understanding of intelligence, there is no longer any association between their belief in the effect of effort and that of ability. Their results were not inconsistent with the findings of other studies (Malmberg et al., 2008; Nicholls, 1978) that describe students at the age of 9 to 10 years developing an understanding that ability and effort combine to influence outcomes.

Pomerantz and Ruble (1997) interpreted theory-of-intelligence as a person's belief "about the extent to which they feel their intelligence is not under their control" (p. 1165). Interpreting intelligence as synonymous with ability, they assessed three related aspects: conceptions of ability as uncontrollable, as constant, and as capacity. However, the findings relating to theory-of-intelligence (conceptions of ability as uncontrollable) are doubtful because no factor analysis was reported and only two items were used: "Kids who are smart in school are born that way" and "You can't really change how smart you are" (p. 1169).

A final interpretation of theory-of-intelligence is that used in Ziegler and Stoeger's (2010) pair of studies with a total of 596 students at secondary schools (Gymnasiums) in Germany. Dweck's three entity-belief items were translated into German (and then translated back to English for the journal article), and modified to relate specifically to mathematics. For example, one item was "Everyone has a certain amount of ability for mathematics and there is not much that can be done to really change that" (p. 320). Also measured were students' beliefs about the stability of existing mathematics attainment ("After I have learned something in mathematics, I don't forget how to apply it"), and their beliefs about whether ability deficits could be modified ("In math class, I can compensate for knowledge deficits by studying more", p. 320). An array of eight additional measures included achievement and aspects of motivation. Their regression analysis indicated that students' incremental beliefs were a significant predictor of the mathematics grade to which they aspired, but did not predict actual grades. Instead, students' beliefs about the modifiability of their ability deficits specifically, proved to be a significant predictor of mathematics grades, and of several motivation-related variables. Ziegler and Stoeger's findings supported a further distinction to Dweck's theory that an entity belief has negative consequences and an incremental belief, positive consequences. Rather than an entity theory-of-intelligence having negative consequences across the board, they found that the only negative effect of an entity belief was when students believed they could not improve their perceived deficits. Their findings indicated that theory-of-intelligence might be more complex than is suggested by its treatment in research, and that for students who perceive their abilities as adequate or superior, a fixed view of intelligence might not have negative effects on achievement.

Measuring students' beliefs about the malleability of intelligence

In the majority of theory-of-intelligence studies with primary students, questionnaires in which students respond to statements using a Likert-type scale have been used. Unlike mathematics self-efficacy, which is best assessed on a task-specific basis, it appears that students' beliefs about intelligence need not be task specific, or even domain related (Stipek & Gralinski, 1996). As a result, a measure of students' beliefs about intelligence that has been used with one group of students has often been used with other students of similar ages. Dweck's items are a case in point.

To measure theory-of-intelligence, Dweck (2000) recommended the six items in Table 3.1, for use with students of 10 years and older. Other than being positively or negatively worded, there are no substantial differences between any of these items. Dweck maintained that theory-of-intelligence could be reliably assessed using the three entity-belief items (first in the list above), for which a factor analysis was reported in Dweck et al. (1995). Other researchers (Ablard, 2002; Ahmavaara & Houston, 2007; Gonida, Kiosseoglou, & Leonardi, 2006; Law, 2009; Shih, 2007; Vogler & Bakken, 2007) have used these three items to assess students' entity theory-of-intelligence.

Few other researchers who have investigated students' beliefs about the malleability of intelligence have included full lists of questionnaire or interview items, or reported factor analyses, in accounts of their research. A second published study that included a complete list of items, along with a factor analysis of the items, was Stipek and Gralinski's (1996) study, described earlier. Their items have been adopted by other researchers for use in subsequent studies (for example, Kärkkäinen, Räty, & Kasanen, 2008), sometimes in modified form (for example, Abdullah, 2008; Leonardi & Gialamas, 2002; Malmberg et al., 2008).

A novel approach to assessing theory-of-intelligence was described by Ablard and Mills (1996), reporting their cross-sectional study of academically talented students. They made the point that theory-of-intelligence has typically been assessed using items that are clearly either entity-belief or incremental-belief oriented, imposing what they claimed was a false dichotomy. Their solution to this was to tackle the question more directly and ask 8 to 17-year-olds to rate the stability of intelligence using a 6-point Likert-type scale that was anchored at 1 with *stays the same*, and at 6 with *changes a lot*. In the same questionnaire, they also assessed students' perceptions of the effort they expend, their preference for challenge, and their

perceptions of their ability. However, they used a single item to assess each of these four factors, giving weak support to their claim that students' perceptions of the malleability of intelligence are a continuous rather than dichotomous variable. Although the present study will show that there may be merit in asking students how much they think intelligence can change, data from this single Likert-type item needed to be strengthened, perhaps by the addition of qualitative data, in order for the findings to have greater rigour.

Whether a researcher decides to use items that focus specifically on the malleability of mathematical intelligence or items that conceptualise intelligence more globally, there are issues that are particular to their use when a study's participants are primary-age students. Key considerations are how young students might understand the word *intelligence*, their likely lack of familiarity with using Likert-type scales, and confusion that might be caused by presenting students with a mixture of positively and negatively-worded items.

Stipek and MacIver (1989) suggested that young students have not yet reached a high enough level of cognitive functioning to have developed a concept of intelligence, and so may not understand the word *intelligence*. To address this difficulty, words like *smart* and *clever* have been substituted for *intelligence* to make questionnaire items accessible to younger students in the US and UK, respectively (Burke & Williams, 2009).

Researchers have found various ways of making rating scales accessible to younger students, especially those who were not yet fluent readers. Droege and Stipek (1993) interviewed students between 5 and 12 years old, and asked them to rank their classmates according to how "smart in schoolwork" (p. 648) they thought they were. The younger students did this by putting their classmates' names into a series of five bowls, the smallest representing students who were not smart at all, and the largest bowl representing students who were very smart. Older students did this as a written task, using a 5-point Likert-type scale. The interviewer then asked the students several questions related to the malleability of intelligence of students given different ratings, such as how smart did they think this student would be next year, and how smart would they be if they changed school. Students were also asked about the potential of effort to increase their classmates' achievement with questions such as whether a classmate from the second bowl could be as smart as a classmate from the third bowl if they worked hard, and whether they could be as smart as a classmate from the fifth bowl if

they tried hard. The findings indicated that it was not until students reached around 11 to 12 years that their responses indicated limitations of effort for improving achievement.

Using a method that might fall somewhere between using bowls and presenting students with a written rating scale, Kinlaw and Kurtz-Costes (2007) represented a Likert-type scale with a series of five circles of increasing size, the smallest circle intended to signify *I really don't agree*, and the largest, *I really agree*. Students from 5 to 10 years old were shown two pictures of students, described by the interviewer to have either an entity or incremental theory. Students indicated how much they agreed with the views the interviewer described by pointing to the appropriate circle.

Still another method that has been explored with younger students is the use of puppets. Brown identified what she called the emergent theory-of-intelligence of 103 preschool children by having the youngsters choose which of two puppets made comments most similar to their parents' about their attempts at solving four puzzles, the first three of which were actually unsolvable. One puppet made performance-focused comments, and the other's focused on effort. A child's choice of puppet was interpreted as a sign of emergent entity or emergent incremental theory-of-intelligence, respectively. Following this, the children were asked to choose which puzzle they would like to spend more time on, if they were given an opportunity. This was seen as an indication of challenge-seeking or challenge-avoiding behaviour. However, it seems that what was being measured in this study was actually parents' theory-of-intelligence, not children's. Although the two might be associated, this has not yet been shown empirically.

Mixing negatively-worded entity-belief items and positively-worded incremental-belief items is another potential problem as it may cause confusion to younger students. Dweck and her colleagues addressed this by presenting entity and incremental belief items on separate pages, or by using only the three entity-belief items. Various strategies have been used to overcome potential issues related to young students' limited reading abilities, emergent understanding of intelligence, and their ability to use a Likert-type scale to show their responses to questionnaire items. In addition, the ways in which they have been analysed have also varied.

Issues of data analysis and interpretation

The biggest problem with the ways theory-of-intelligence data have been analysed is that ordinal data from Likert-type items have generally been treated as quantitative data and analysed using means-based tests designed for interval data, such as analysis of variance. Interview responses have been categorised and subsequently treated the same way. Compared to the self-efficacy research reviewed in the previous chapter, a greater number of studies focussing on students' beliefs about intelligence have used interviews to collect data. Although interviewing might often be thought of as a qualitative method, the data have typically been quantitised to the point of virtually stripping them of their original voices.

Another issue is that ordinal theory-of-intelligence data have often been treated as dichotomous. For example, Dweck et al. (1995) analysed data from six validation studies, all of which had presented participants (ages not stated) with the three entity-belief items, presented earlier, and used a Likert-type scale ranging from 1 (strongly agree) to 6 (strongly disagree) for their responses. In each of the studies, the data were then dichotomised by using each participant's average score and classifying those with a score of 3.0 and below as having incremental beliefs, and those with 4.0 and above as entity theorists. Typically this resulted in the exclusion of 15% of participants, and presented the data as dichotomous even though "the two theory groups do not represent extreme groups" (Dweck et al., 1995, p. 269). Pepi, Alesi, and Geraci (2004) also took a dichotomous approach to analysing and interpreting the theory-of-intelligence data from their study of Italian students with reading disabilities. Dichotomising theory-of-intelligence data to either entity or incremental beliefs misrepresents participants' beliefs, and ignores the complexity of students' thinking about the malleability of intelligence.

One reason that data have been dichotomised might be that very few people with strong entity beliefs have been identified. For instance, Blackwell et al. (2007) took the mean incremental theory-of-intelligence score of each student's six 6-point Likert-scale items, and found that in Study 1 the mean of these was 4.45 and the standard deviation was .97, while in Study 2 the mean score was 4.49 (no standard deviation was given). In Dweck et al. (1995), mean scores for the six studies from 3.57 (standard deviation: 1.49) to 3.97 (standard deviation: 1.13) were reported. These means suggest that students' scores tended towards the upper end of the

range of 1 to 6 scores, with few students showing extreme entity beliefs. No information regarding quartiles was provided in either case.

In some studies, students' responses in interview situations have been quantitised by coding them on Likert-type scales, and then treated as quantitative data (Brown, 2009; Droege & Stipek, 1993; Kinlaw & Kurtz-Costes, 2007). In two mixed-methods studies from Finland (Kasanen, Räty, & Eklund, 2009; Räty, Kasanen, Kiikinen, Nykky, & Atjonen, 2004), categories for coding the qualitative data, elicited by asking students open-ended questions, were formulated from responses and were illustrated with examples. These were then coded according to whether or not each student had included them in their responses, and treated as categorical data which were subsequently compared to the ordinal data from Likert-scale items. As described earlier, Kurtz-Costes et al. (2005) analysed data from structured interviews in a similar way.

Because in many instances parametric statistical analyses have been applied to ordinal, and even categorical, data, the findings from the studies in question must be dubious, at best. This casts considerable doubt on the claims made about the findings of such studies regarding theory-of-intelligence.

School-related factors that contribute to students' beliefs about the malleability of intelligence

Unlike self-efficacy, no statistical analyses have been used to help determine the relative contributions that different factors might make to a person's theory-of-intelligence. For instance, a student's interactions with, and observations of, their family members and their peers probably contribute to their beliefs about the malleability of intelligence. Whether their effect is greater than that of factors in the student's school environment is unknown.

Students' beliefs about intelligence do not develop in isolation from wider society and in particular, from their school context. Aspects of a school environment that are likely to play a role in shaping students' theory-of-intelligence include curriculum differentiation, ability-based groupings, and assessment practices. In their comparison of American classrooms with those in China and Japan, Stevenson and Stigler (1992) found that American teachers adjust the curriculum so that students of lower ability are not expected to attempt tasks they might struggle with. In contrast, there was no curriculum differentiation in the Asian classrooms, where

students were expected to keep up with their peers by working hard. They also maintained that Americans valued more highly a child's all-round "life adjustment and the enhancement of self-esteem" (p. 111) than their academic learning, whereas in China and Japan the clear purpose of school was for children to learn key academic skills – reading, writing, and mathematics. So curricula in the US are designed to cater for students who excel and others who struggle with academic work, whereas schools in China and Japan expect all students to succeed, to varying degrees.

Primary schools in a Western system generally allocate students to class groups according to age rather than attainment of set standards, and this provides students with opportunities to compare themselves with their peers in terms of academic ability (Malmberg et al., 2008, p. 532). In Germany, the wider school system is explicitly stratified according to ability for the purpose of closely matching instruction with ability. The grades a student gains by the end of primary school largely determine their secondary school track, which in turn affects their possibilities for university enrolment and, later on, lifestyle. Malmberg et al. explored how school type might be associated with students' beliefs about ability and effort, and found that students towards the end of primary school tended to have an entity theory and to believe in the value of effort. Looking at the secondary school students, they observed that Gymnasium students (in the track intended for later university enrolment) believed ability was fixed less than students in other types of schools did (those destined for vocational training), and appeared to apply effort to maximise their ability. Students in schools destined for vocational training might believe that applying effort is futile and tend more towards an entity theory, because their possibilities have been limited by the end of primary school.

The New Zealand education system is somewhat more flexible, and it is possible to pursue tertiary study even after academic failure at school. This possibility could promote greater optimism about the malleability of intelligence than the very structured German system. Ability-based grouping is nonetheless a feature of most New Zealand primary classrooms, and students are generally ability grouped for mathematics and for reading instruction. In the Numeracy Development Projects, teachers were encouraged to "Group your students for instruction by their assigned strategy stages for addition and subtraction" (Ministry of Education, 2008d, p. 11), and strategy stages are implicitly linked to ability**.** A student's awareness of their class ranking for mathematics is likely to be associated with the group in which they

are included, informed by their perceptions of the abilities of peers in the same group, and by the interactions the teacher has with them in that context.

Writing about the relationship of effort and ability, Nicholls (1978) linked a competitive education system that emphasised normative evaluation, with inevitable inequality of effort amongst students as they progress through school. He proposed that the "higher motivation of high achievers appears dependent on the presence of low achievers for whom the presence of high achievers leads to a lack of motivation" (p. 811). Without empirical studies, it is not possible to say whether or not ability-based grouping for mathematics instruction might have a similar effect in New Zealand primary schools.

As students move into senior primary school, assessments become more formal and frequent (Midgley, Anderman, & Hicks, 1995) and take on greater importance for all concerned – students, teachers, and parents. One of the consequences of assessment is that students can be, and often are, ranked in terms of ability. As Kurtz-Costes et al. (2005) stated:

> Early testing that draws the attention of children, parents, and teachers to individual differences in current achievement levels will reinforce beliefs that the most important end product of education is not learning, but grades, and that achievement tests measure intelligence, which is likely to be perceived as not particularly malleable. (p. 230)

In Droege and Stipek's cross-sectional (1993) study, students were asked to rank their classmates in order of ability, and this information was checked against their teachers' judgments. Students' rankings were found to be a close match with their teachers' judgments, even for the third graders. This is fairly consistent with an earlier study (Boehm & White, 1967) that found students in fourth grade had quite clear ideas about where they stood academically in relation to their peers. For younger students, they found their awareness of class ranking was less secure. The students in both studies would be at around the third level of reasoning proposed by Nicholls (1978), probably beginning to differentiate ability from effort. Taking this into consideration, it is not surprising that younger students did not rank their peers as their teachers did.

Effects of teacher-student feedback

In Dweck's early (1975) work, teacher-student feedback that emphasised the role of effort was used to help shape students' attributions in failure situations, with results showing that students subsequently tended to attribute failure to lack of effort, and responded by showing increased persistence. Other studies have confirmed the considerable effects of teacher feedback on student attributions (Elliott & Dweck, 1988; Mueller & Dweck, 1998; Robertson, 2000). In a series of six experimental studies, Mueller and Dweck (1998) investigated the effects of experimenters praising students for their intelligence and praising them for effort in success and failure situations. In particular, they observed students' subsequent task choices, and whether these reflected a desire to learn or to perform well. They reported that students who received intelligence-focussed praise tended to choose performance tasks, whereas those whose effort was praised chose more challenging tasks, regardless of whether they had just succeeded or failed on a task.

The effects on students' ability conceptions of adults' verbal descriptions of other students' performances in mathematics were the subject of three experimental studies involving 8 to 12-year-olds (Heyman, 2008). Heyman pointed out that feedback to students provides them with information they use to help develop an understanding of their successes and failures. For instance, she suggested that "a child who hears that a peer's success in math is a consequence of being "gifted" may reason that her own lack of success is due to a lack of innate ability" (p. 367) – of not having this particular "gift". The flipside of labelling a student "gifted", according to Mueller and Dweck (1998), is that this can cause them to focus on continually proving that their ability merits this label, instead of taking on challenges and developing their skills. A key finding of Heyman's research was that teachers labelling students who were successful with names such as "maths whizz" seemed to be associated with other students having an entity theory-of-intelligence. On the other hand, when references were made to high achievers overcoming their previous difficulties, this appeared to have the effect of making other students more optimistic about succeeding in mathematics.

In their study of Finnish 9 and 12-year-old students' beliefs about the malleability of their academic abilities, Kärkkäinen et al. (2008) suggested that:

> Although the school studiously attempts to avoid all normative feedback and related comparisons during the two elementary years in particular, its everyday practices in fact contain numerous routines and test-like situations that convey essentially normative assessment criteria and comparative feedback to the pupils. (p. 455)

Comparing one's achievement to others' is one way of evaluating ability. Bong (2009) suggested that students begin to include social-normative information in evaluations of their ability at around 10 years old, about the same age at which they are thought to develop an understanding of ability (Nicholls, 1978). An alternative to these normative judgments is for a student to compare their progress to clearly-stated, specific learning intentions, and to receive teacher feedback in relation to these. Teacher-student feedback has also been emphasised as an important component of quality teaching in New Zealand (Alton-Lee, 2003; Hattie, 1999; Hattie & Timperley, 2007).

Reported effects of students' beliefs about the malleability of intelligence

Achievement goals

According to Bempechat, London, and Dweck (1991), a student's theory-of-intelligence largely determines their goal orientation. Students with an incremental theory-of-intelligence tend to espouse learning goals that focus on mastery of knowledge, skills, and strategies, and they are not averse to risk making mistakes. In contrast, students with an entity belief focus more on performance goals and are concerned with avoiding negative judgments of their competence, so are risk avoidant (Dweck & Leggett, 1988; Elliott & Dweck, 1988), avoiding failures that could undermine their appearance of being "smart" (Ames & Archer, 1988). Following this line of thought, entity-belief students (if they exist) are likely to see no point in trying to increase their supposedly permanently-set intelligence.

The types of goals students choose are important, because goals are associated with learning outcomes. In 1988, Elliott and Dweck's experimental study examined the effect of performance and learning goals, combined with ability feedback, on the achievement of 101 students. The 10 to 11-year-olds were in one of four treatments that varied by feedback that their skill level for a given task was either high or low, and by instructions that emphasised the importance of either performance or learning goals. Students were given a choice of tasks and were told

that one group of puzzles they should be able to do but might not learn from, and the other group might be confusing and difficult at times but they would learn from doing them. Students in the learning goal treatments, regardless of the skill feedback they had received, tended to opt for the challenging puzzles, taking up the opportunity to learn something new and risking making mistakes in front of the experimenter. Elliott and Dweck concluded that the different types of goal each "runs off a different "program" with different commands, decision rules, and inference rules, and hence, with different cognitive, affective, and behavioural consequences" (p. 11). Achievement-wise, their results showed that students' problem-solving strategies improved for those with learning goals, as did strategies of the performance goal students who had been given high-ability feedback. A significantly smaller percentage of those who were in the performance goal plus low-ability feedback treatment showed an improvement in strategies. What was particularly interesting about their results was that the performance-goal students who received feedback about their high ability showed improved strategies, suggesting that perhaps for some students ability-focussed feedback – consistent with an entity theory-of-intelligence – may actually support aspects of their achievement. Although these students showed persistence with tasks they found difficult, Elliott and Dweck found they did not take advantage of opportunities to learn new skills that involved public mistakes, and instead opted for easier tasks.

A student's goal orientation shapes their pattern of response to success and failure situations (Elliott & Dweck, 1988). Typically, a student with a learning goal orientation attributes their results to the effort they expended and the strategies they used, so if they initially fail, their response is likely to be to try harder or to use a different strategy. Such situations can in fact increase a student's feeling of self-efficacy: when they succeed, this is attributed to how hard they worked, and there is a long-term positive impact on their self-efficacy.

In contrast, Dweck (2000; Elliott & Dweck, 1988) described a student with a performance goal orientation as tending to attribute their outcomes to their ability, with effort playing little or no role. Their response to failure will probably include such behaviours as giving up, showing negative affect, and choosing an easier task, and will be accompanied by a drop in their self-efficacy levels. When they attribute their successes to their intelligence, this has a positive but temporary effect on self-efficacy, because the student with an underlying entity theory-of-intelligence is only as good as their last performance; they are constantly looking

for opportunities that will show what they can do, rather than opportunities to develop their inherent intelligence. A student with an incremental theory-of-intelligence, on the other hand, recognises challenges as opportunities to learn, and seeks them out, according to Dweck (2000).

Although Stipek and Gralinski's (1996) study found that entity beliefs were negatively associated with achievement, they found only limited support for the hypothesis that the effect of entity beliefs was mediated by a performance goal orientation. Furthermore, they suggested that it should not be assumed that because a mastery goal orientation is associated with higher achievement than a performance orientation, that it is necessarily a bad thing in every student's case to have a performance goal orientation. Related to the suggestion that a performance goal might not always have negative consequences for students' learning, Bong's (2009) study of 1,196 Korean students showed that students in the first four grades tended to endorse mastery-approach goals ("approach" signifying these goals were construed by students as having positive possibilities, compared with "avoidance", indicating the perception of negative possibilities). In contrast, students in Grades 5 to 9 tended to endorse performance-approach goals. What was interesting about the findings from this study was that they indicated that both mastery-approach and performance-approach goal types were positively correlated with students' self-efficacy and mathematics achievement. The study did not include a measure of students' theory-of-intelligence. It is highlighted here because it casts some doubt on the desirability of particular goal orientations, which have in turn been linked to beliefs about the malleability of intelligence.

Task choices and persistence

Elliott and Dweck's (1988) experimental study found that for students who tended to have more of an entity theory-of-intelligence, effort and making mistakes were equated with lack of intelligence. In addition, their self-efficacy tended to be more fragile, and they were likely to avoid challenges because these demand effort and they risk making mistakes. For students who believed that intelligence is a fixed entity, their perception was that it is beyond their control to influence their achievement outcomes. In contrast, students with more of an incremental theory-of-intelligence believed they can influence the development of their intelligence through effort and the use of strategies, so were likely to have strong self-efficacy. These students genuinely want to engage in the learning process, rather than

wanting to look smart by error-free performances, and they are more likely to seek challenges and persevere at difficulty, as Smiley and Dweck (1994) also found.

Cain and Dweck's (1995) study, described earlier, also investigated the relationship between persistence and theory-of-intelligence, presenting 139 students from 6 to 11 years old with a series of four puzzles, three of which were unsolvable. After students had worked for a limited amount of time on each of the puzzles, they were offered an opportunity to return to the puzzle of their choice. Students who tended towards an entity belief chose to repeat a puzzle they had previously solved, while those with more of an incremental belief were more likely to return to a puzzle they had previously been unable to finish, indicating greater persistence. Students in the former group also expressed lower expectations for success in the future. Interestingly, it was not until the fifth grade that students' helpless and mastery orientations were associated with an entity and incremental theory-of-intelligence, respectively. Other work (Diener & Dweck, 1978, 1980; Smiley & Dweck, 1994) has shown an association between students' goal orientation and their responses after failure, and between persistence after failure and attribution to effort or ability (Weiner, 1985).

Student achievement

Empirical research has yet to establish clear causal links between students' theory-of-intelligence and achievement. Associations between the theory-of-intelligence and achievement of students in the 8 to 15-year-old range have been reported, although in some cases, the data analysis methods used were less than rigorous. Cury, Elliot, Fonseca, and Moller (2006) conducted two studies of achievement motivation with 12 to 15-year-olds in France. They measured what they called students' *implicit theory of ability* using three incremental and three entity items which were mathematics related. For instance, one entity item was, "One has a certain level of ability in math, and there is not much one can do to change it" (p. 669). A factor analysis showed a two-factor structure: entity and incremental theory-of-intelligence. Also measured were the 209 students' perceived competence, achievement goals, and mathematics grades. Their findings strongly supported their hypotheses that an entity theory-of-intelligence would negatively predict achievement, and that an incremental belief would be a positive predictor. Similar results have been found with university undergraduates (for example, Aronson, Fried, & Goode, 2002).

Gonida et al. (2006) assessed 10 to 12-year-old students' theory-of-intelligence, mathematics achievement, and perceived competence on two occasions, 1 year apart. Perceived competence was measured with five items such as "Some children believe that they are very good in their schoolwork but other children believe that they are not so good in their schoolwork" (p. 229). They conducted their own factor analysis of Dweck et al.'s (1995) three entity items, used in the study, with loadings of .70 to .83 indicated. A factor analysis of the perceived competence items also showed loadings on a single factor that ranged from .52 to .84. A regression analysis showed that prior achievement predicted theory-of-intelligence, and prior theory-of-intelligence predicted achievement. Their findings add to those of earlier studies that had focused on the association of theory-of-intelligence and achievement, and suggest that theory-of-intelligence and achievement might be reciprocally related.

Blackwell et al. (2007) compared the trajectories of students' mathematics achievement to their theory-of-intelligence, in two longitudinal studies over the 2 years of junior high school in the US. In both studies, surveys were used to measure students' theory-of-intelligence, learning goals, effort beliefs, responses to failure, and mathematics achievement. One of the studies also included an intervention that aimed to explicitly teach an incremental theory-of-intelligence. Structural equation modelling was inappropriately used to analyse the ordinal data. Findings from both studies indicated that an incremental belief was associated with higher achievement in mathematics than an entity theory. Similarly, an investigation involving Chinese 12-year-olds (Law, 2009) found that incremental beliefs about intelligence were positively correlated with reading comprehension. What these studies appeared to show was that, where participants are between 10 and 13 years old, an incremental theory-of-intelligence seems to be positively associated with achievement.

Stipek and Gralinski's (1996) research, described earlier, found that students' theory-of-intelligence is probably not subject specific. They suggested that although an incremental or mastery orientation has been shown to be associated with positive effects on learning, this does not mean that an entity or performance orientation is necessarily a bad thing for every student. More research is needed to identify which students might reap the greatest benefits from particular beliefs about intelligence, and why this might be so.

Trends in students' beliefs about the malleability of intelligence

From empirical studies, data have been used to suggest trends in theory-of-intelligence related to age and maturation, and gender, with some overlap at times. Differences according to age and gender were also investigated in the present study, whereas ethnicity was not a focus.

Age and maturation

It has not yet been possible to disentangle the effects that maturational and environmental influences, such as a student's experiences at school, exert on theory-of-intelligence. Trends in theory-of-intelligence related to age suggest that at a stage in their lives when students do not yet have an understanding of intelligence, most young students tend to indicate an incremental view of intelligence, suggesting that they believe they can change how clever they are (Dweck & Elliott, 1983; Pintrich & Schunk, 1996). Young students are more optimistic about improving their academic outcomes than are older students (Kärkkäinen et al., 2008). Research by Kurtz-Costes et al. (2005) found that 13 to 14-year-old students in both Germany and the United States were more likely than 10 to 11-year-old students to perceive intelligence as an entity trait, and two other studies (Ablard & Mills, 1996; Leonardi & Gialamas, 2002) involving pre-adolescent students and teenagers found that the younger students were more likely to believe that intelligence could be increased through effort, while the older students believed intelligence was fairly stable. Collectively, the research literature builds a picture of students beginning school with a theory-of-intelligence that tends towards incremental and moves towards an entity belief as they progress through their education.

There are a few exceptions to this pattern, though, with three cross-sectional studies (Bempechat et al., 1991; Cain & Dweck, 1995; Pomerantz & Ruble, 1997) finding no significant grade differences in theory-of-intelligence. A cross-sectional study in Scotland (Burke & Williams, 2009) found that the 5-year-old participants were more likely to believe in the stability of intelligence than the 7 and 11-year-olds. However, this was based on students' responses to the item, "If someone is clever, they will always be clever" (p. 958) which might also be interpreted as asking whether it is possible for intelligence to decrease. This is quite a different question to asking students whether or not they can change their intelligence, which implies increasing intelligence. The other theory-of-intelligence item in their

study asked, “If someone is not clever, can they change to get cleverer?” which is closer to Dweck’s items. But with just two theory-of-intelligence items included, and a relatively small sample of 75 students, it is not possible to draw any conclusions from the study.

There are several factors which might be associated with a trend towards an entity theory-of-intelligence as students get older. At intermediate and secondary school, individual achievement results take on heightened importance, and failures can have significant long-term consequences. In primary school, on the other hand, students in the West are often protected from failure. Another factor might be the effect of maturation on students’ developing concepts of intelligence. Bong (2009) suggested that this apparent shift during early adolescence “might begin to set in motion only after children learn to recognize and appreciate the potential benefits of achieving success with less effort” (p. 892). An alternative explanation is that the items typically used for measuring students’ theory-of-intelligence do not reflect the complexity of students’ beliefs about the nature of intelligence, particularly if their definitions of intelligence are multidimensional, as proposed by Sternberg (1985a).

Whether this shift towards an entity belief is the effect of maturation or environmental factors, or some combination of both, is uncertain, and can be reliably established only by longitudinal studies, of which there have been a small number (for example, Ablard, 2002; Blackwell et al., 2007; Pomerantz & Saxon, 2001). Longitudinal studies are logistically more difficult to conduct than studies involving one-off measures, and as an alternative, some studies (for example, Cain & Dweck, 1995) have tried to build an overview of how theory-of-intelligence changes by conducting cross-sectional studies. One cross-sectional study that included measures of theory-of-intelligence and self-efficacy (Midgley et al., 1995) investigated relationships between the two for 969 US elementary and middle school students, from Grade 4 to 7. Midgley et al. were interested to see whether the goals students emphasised were associated with their self-efficacy and beliefs about the malleability of what they termed *school ability* – students’ general ability at school. Self-efficacy was also interpreted as being general in nature, relating to general school work. Using path analysis, they found that for elementary students, a belief that school ability is malleable does not predict self-efficacy. In comparison, for middle school students, path analysis indicated an incremental belief in school ability was associated with students’ self-efficacy. Midgley et al. found that students’ beliefs about ability and self-efficacy were associated for middle school

students, although not for elementary students. They did not, however, collect student achievement data, so were unable to comment on how these student beliefs might have been associated with their achievement.

Longitudinal studies of varying length have aimed to identify how theory-of-intelligence is associated with students' achievement over the primary school years. In Stipek and Gralinski's (1996) study, described earlier, the mathematics and social studies achievement of primary students, and their beliefs about the malleability of intelligence, were assessed twice over 1 school year. Their findings indicated that an entity belief was a negative predictor of achievement.

In another study (Pomerantz & Saxon, 2001) that spanned 12 months, with three data collection points and involving 932 fourth to sixth-grade students, there was a tendency for low grades to be associated with a conception of ability as unaffected by internal forces, such as effort. On the other hand, high grades tended to be associated with a conception of ability as unaffected by external forces, such as situational changes. Had students also been asked about their definitions of – in this case – ability, this might have illuminated their reasons for these different beliefs, and whether students' definitions might in turn be associated with their achievement.

The participants in Gonida et al.'s (2006) study were similar ages to those in Pomerantz and Saxon's (2001) research. Gonida et al. (2006) investigated the relationship between theory-of-intelligence and achievement in mathematics and language, with two data collection points 1 year apart. They found that high achievers in their sample of 10 to 12-year-olds "adopted more incremental beliefs and had significantly higher perceived competence" (p. 223) than other students.

Finally, in one of a pair of studies, Blackwell et al. (2007) examined how the theory-of-intelligence of four cohorts of seventh graders (373 students in total) was associated with changes in their mathematics achievement during the 2 years of junior high school. According to their findings, "an incremental theory-of-intelligence at the beginning of junior high school predicted higher mathematics grades earned at the end of the second year of junior high school" (p. 251).

Taken collectively, the findings from the longitudinal and cross-sectional studies seem to indicate that there is a tendency for students from around 8 to 12 years with an incremental belief to have better academic outcomes than students with an entity belief. However, the studies described earlier in this section showed that

students tend to shift towards an entity theory-of-intelligence as they get older. Not all students have entity beliefs about intelligence by the time they leave primary school though, so it is unlikely that theory-of-intelligence is related to maturation alone. As Dweck (2002) pointed out, “it cannot be all a matter of cognitive advancement” (p. 84), or all adults would be (comparative) entity theorists.

Gender

The findings related to gender and theory-of-intelligence are somewhat mixed. A number of studies (Ablard & Mills, 1996; Kärkkäinen et al., 2008) that have included students from 5 to 12 years old have detected no significant differences between girls’ and boys’ beliefs about the malleability of intelligence. Focussing on academically talented students, Ablard’s (2002) longitudinal study found that 425 12-year-old girls and boys espoused a similar range of learning goals and performance goals, which was associated with their having a similar range of beliefs about intelligence.

Other research in a mathematics context has indicated that girls seem to tend towards an entity theory-of-intelligence more than boys do. Stipek and Gralinski (1991) assessed students’ beliefs about whether applying effort might improve their achievement in mathematics, using two items: “Everyone could do well in math if they worked hard” and “A few kids will never do well in math, even if they try hard” (p. 363). Also assessed were students’ attributions for the outcome they expected from a mathematics exam. They found that boys were more likely than girls to attribute success to high (malleable) ability and failure to luck, and were also more likely to believe applying effort could result in success. Girls, in contrast, were more likely to attribute success to luck, and failure to low (fixed) ability. In a more recent study, Räty et al. (2004) also observed that “the boys had a stronger belief than did the girls in effort as a way of improving one’s performance in mathematics” (p. 424) Räty et al. compared students’ beliefs about their potential for improvement in mathematics and in Finnish, and interestingly found no difference in students’ language-related beliefs that was associated with gender.

According to Dweck (1986), girls tend to have an entity theory-of-intelligence, and are more likely than boys to attribute failure to ability (Dweck & Leggett, 1988). The role that stereotypes might play in forming students’ attributions for their performance in mathematics is difficult to isolate, but Dweck (2006) has suggested that these might affect girls’ perceptions of their ability in mathematics.

Research methods used to investigate students' beliefs

Mixed methods have not been widely used to investigate primary students' theory-of-intelligence. The two Finnish studies just mentioned (Kasanen et al., 2009; Räty et al., 2004) collected qualitative and quantitative data, but did not explicitly discuss how the data were mixed in their studies. No sequential mixed-methods studies of primary students' theory-of-intelligence, including separate quantitative and qualitative methods, have been published.

In studies in which data about theory-of-intelligence have been collected by interviewing students, it has usually not been feasible to include the large sample sizes or multiple waves of data collection, more typical of quantitative studies. To illustrate these points, on just one occasion, Kasanen et al. (2009) interviewed 58 students, Burke and Williams (2009) interviewed 75 students in their study, and Räty et al. (2004) interviewed 119. In each of these studies with primary-school students, only qualitative data were collected, and these subsequently underwent a content analysis process.

Interventions to develop an incremental theory-of-intelligence

What is of particular interest in the present study is how primary students' beliefs about the malleability of intelligence might be associated with their achievement in mathematics, therefore interventions that are of interest are those that include measures of both mathematics achievement and theory-of-intelligence in a primary-school setting. A single experimental study (Blackwell et al., 2007) has explored the possibility of explicitly teaching an incremental belief to 12 and 13-year-olds, who in New Zealand would be at the very upper limit of the primary years. Typically, as students this age make a transition to secondary school, their achievement dips slightly (see, for instance, Cox & Kennedy, 2008)**.** To see if they could counteract this, Blackwell et al. explicitly taught an incremental belief to 91 relatively low-achieving seventh-grade students, in eight weekly 25-minute sessions. Initially, students in the experimental and control groups were presented with the same workshops, focussed on study skills, and the brain's physiology. Then the experimental group participated in sessions that focussed specifically on the malleability of intelligence, with the key message being "that learning changes the brain by forming new connections" (Blackwell et al., 2007, p. 254). In the meantime, those in the control group studied memory.

Theory-of-intelligence data were collected at the beginning and end of seventh grade, and three sets of mathematics achievement data were collected – students' end of sixth-grade data, plus start and end of seventh grade. Theory-of-intelligence was measured using Dweck's (2000) six items – three entity and three incremental belief items. The results showed that students in the experimental group experienced a boost to their mathematics achievement by the end of seventh grade, as well as enhanced motivation during class. The achievement of students in the control group, on the other hand, had continued to decline.

Given the volume of research relating to students' beliefs about the malleability of intelligence, and the messages in the research literature about the need to teach students about the value of effort and their capacity to learn – ideally before they reach secondary school – it is curious that so few interventions have been explored with primary-school students. A small number of experimental studies have taken pre- and post-intervention measures of students' beliefs about the malleability of intelligence to see what the effects might be of manipulating a variable, such as feedback (Heyman, 2008; Heyman & Compton, 2006), with which students' beliefs about the malleability of intelligence are thought to be associated. The focus of these studies, however, was not on the association between changes in theory-of-intelligence and achievement.

Connecting students' beliefs about intelligence, their mathematics self-efficacy and their mathematics achievement

In their study of Grade 6 science, Chen and Pajares (2010) identified the role of students' epistemological beliefs in mediating the effect of theory-of-intelligence on self-efficacy and achievement in science. Students' theory-of-intelligence was related to their beliefs about scientific knowledge, with entity beliefs being associated with naïve views of the nature of scientific knowledge, and incremental beliefs with more sophisticated views. Students' beliefs about the nature of science were in turn associated with their self-efficacy for science, and their achievement.

The effect on a person's self-efficacy of believing intelligence is a fixed entity has also been investigated in the context of adults encountering difficulty (Wood & Bandura, 1989). In their experimental study, 24 business studies graduates were given managerial decision-making roles in a simulated organisation. Before the simulated business scenarios were presented to participants for them to manage, one group was told that the skills they would need could be learnt, while the other

half of the sample was told the necessary skills were related to fixed intellectual capacity. Wood and Bandura found that entity beliefs were associated with decreased self-efficacy when participants met with challenges, and that those who were exposed to an incremental theory-of-intelligence persevered at difficulty, and were resilient, with no ill-effects to their self-efficacy levels. In the situations to which they were asked to respond, those who had been presented with incremental beliefs had greater success than those for whom intelligence had been portrayed as an inherent trait.

Research undertaken by Dweck and her colleagues has been thorough in the area of assessing students' theory-of-intelligence but has not compared this to measurements of students' self-efficacy. There does not yet seem to be empirical research that shows whether or not primary students whose theory-of-intelligence has reportedly shifted from more of an entity theory-of-intelligence towards an incremental theory-of-intelligence have actually experienced a corresponding increase in self-efficacy. Although no research has yet explored whether increasing students' self-efficacy might be associated with changes in their theory-of-intelligence, it seems possible that building students' self-efficacy through feedback that emphasises the value of effort may have the potential to shift students' theory-of-intelligence towards an incremental belief.

Researchers have used path analysis procedures to explain the strong influence of mathematics self-efficacy on achievement (Pajares & Miller, 1994; Schunk & Gunn, 1986) for students at undergraduate and primary levels, respectively. Bandura (1986) proposed that self-efficacy is not totally correlated with actual ability, suggesting instead that self-efficacy operates partially independently of ability to determine achievement. Bandura (1993) connected students' mathematics self-efficacy, achievement, and beliefs about ability when he wrote: "Learning environments that construe ability as an acquirable skill… and highlight self-comparison of progress and personal accomplishments are well suited for building a sense of efficacy that promotes academic achievement" (p. 125).

Questions that have been raised about theory-of-intelligence

Although much of the research reviewed in this chapter supports aspects of Dweck's (1986) model, this has not been unanimous. Over the last decade, in particular, researchers have used empirical evidence to question the claim that a person's theory-of-intelligence always predicts their achievement, and that theory-of-intelligence scores always mean the same thing. For example, Ziegler and Stoeger (2010) presented evidence that an entity view was negatively associated with achievement when it was related to a student's beliefs about their deficits. On the other hand, when an entity belief was related to a student's existing abilities, this was positively associated with achievement.

Dupeyrat and Mariné (2005) tested Dweck's model with adults who were returning to school in France. They measured participants' theory-of-intelligence using Dweck et al.'s (1995) entity items, and also included two incremental-belief items which they developed. The sample item provided was "My intelligence is mainly the result of my experience" (p. 49). Although a factor analysis indicated a two-factor structure, it is not clear that the second factor was consistent with an incremental theory-of-intelligence, as they proposed. Also measured were participants' engagement in learning, and their achievement (their exam grades for the four courses they completed). Although Dupeyrat and Mariné's findings were generally consistent with Dweck's model, the "predicted effects of implicit theories of intelligence on goal orientation and cognitive engagement in learning, however, failed to emerge" (p. 43). Dupeyrat and Mariné proposed that if, as Sternberg (1985a) has suggested, people conceptualise intelligence as being multidimensional, it seemed likely that people might believe some aspects of their intelligence are malleable and others, fixed. Unfortunately though, no evidence was provided to support this.

Another question about theory-of-intelligence was raised by Kinlaw and Kurtz-Costes (2007), who proposed that students might endorse elements of both an entity and an incremental theory. The 5 to 10-year-old students in their study indicated stronger beliefs in the malleability of intelligence than they did in its stability. One of the problems with their methods, however, was that just two items were used to measure theory-of-intelligence – one each to gauge how strongly students agreed with an incremental and entity theory-of-intelligence, weakening their findings.

Most of the questions that have been raised relate to the complexity of people's beliefs about intelligence not being reflected in instruments that include Dweck et al.'s (1995) entity belief items. As part of a structural equation model, Blackwell et al. (2007) reported loadings on a single factor of .41 to .79 for the six theory-of-intelligence items advocated by Dweck (2000), suggesting some items were not actually very strong theory-of-intelligence measures.

Chapter summary

There are a number of problems with research into children's definitions of, and beliefs about, intelligence.

First, researchers' definitions of intelligence, and explanations of how it is differentiated from ability, have rarely been provided in published studies. Students appear to develop a conceptualisation of intelligence as a capacity for learning by around 9 years old. Until they do, their supposed theory-of-intelligence score may indicate their beliefs about an intelligence that is defined very differently – one that might, for instance, also include effort. Only two studies (Cain & Dweck, 1995; Kurtz-Costes et al., 2005) investigated how students' definitions of intelligence were associated with their theory-of-intelligence, but the data analysis methods used in the first study were inappropriate for the data gathered, and the second study relied on a single item to measure theory-of-intelligence. Where students' definitions of intelligence are unknown, one cannot be sure exactly what it is that students are making malleability judgments about. If, as students get older they develop multi-dimensional definitions of intelligence, like that described by Sternberg (1985a), or two-dimensional definitions, similar to the working definition given at the start of this chapter, then responding to Dweck's (2000) items would demand some manner of amalgamation of beliefs.

Second, the analysis of theory-of-intelligence data has followed a somewhat specious path. At times, ordinal data have been dichotomised and analysed as quantitative data, and have been used to build a body of research that has misrepresented students' beliefs about the malleability of intelligence as either strongly entity beliefs or strongly incremental beliefs. Therefore, the robustness of the theory-of-intelligence construct seems doubtful.

Third, a small number of longitudinal studies of children's theory-of-intelligence, and a small number employing mixed methods have been conducted, mostly involving students in senior primary school and beyond. There are almost no reports of intervention studies that sought to alter primary students' beliefs about intelligence. As a result, little is really known about how stable or malleable primary students' theory-of-intelligence might be. Very few studies have gathered evidence of associations between primary students' theory-of-intelligence and their self-efficacy beliefs – none of these in the context of mathematics. Dweck's six theory-of-intelligence items are stated in absolute terms, and how Likert-type responses actually represent respondents' beliefs has had little qualitative exploration. In the present study, students' definitions of intelligence, expressed during interviews, were compared to their responses to Dweck's questionnaire items, to explain what responses to such items actually signify.

From around 8 years old, students' theory-of-intelligence is reported to be associated with their achievement in mathematics, and an incremental theory-of-intelligence positively correlated with achievement. Because of this correlation, an incremental theory-of-intelligence is thought to be preferable to an entity belief for all students. However, findings of other studies (Dupeyrat & Mariné, 2005; Kinlaw & Kurtz-Costes, 2007; Ziegler & Stoeger, 2010) have suggested that an incremental theory-of-intelligence may not be equally beneficial to all students' learning. Rather than taking an absolutist approach, further research is needed to identify the particular situations and students for whom different beliefs about intelligence may be of benefit.

CHAPTER 4
Teachers' Beliefs

Introduction

Although the focus of this thesis is on students – their mathematics self-efficacy and achievement, and their beliefs about intelligence – also important to consider is how their teachers' beliefs might be associated with those of their students and, importantly, with their students' achievement in mathematics. This chapter presents key literature related to teachers' beliefs about learning, more specifically, their self-efficacy for teaching mathematics and their theory-of-intelligence. Also considered are the ways in which teachers' beliefs might influence students, and the potential for teachers to capitalise on any such associations in order to build students' mathematics self-efficacy and their incremental beliefs about intelligence. One of these likely avenues is teacher-student feedback, discussed later in the chapter. The challenges associated with changing teachers' beliefs are also explored.

The empirical studies reviewed here include teachers and occasionally pre-service teachers as participants. One of the difficulties with collecting data from practising teachers can be their distribution across different schools, which might have contributed to the small sample sizes in some of the studies (for example, Nespor, 1984; Yerrick, Parke, & Nugent, 1996) presented in this chapter. Although studies in which the participants are pre-service teachers have the advantage of tapping into a large potential sample in the same location, the characteristics of the people in this group are obviously unlikely to include years of teaching experience, which may in itself have quite an effect on teachers' beliefs. Therefore, studies of pre-service teachers alone have not been included in this review.

As was the case in regard to students' mathematics self-efficacy and beliefs about intelligence, issues of interpretation and operationalisation were reflected in the literature related to teachers' beliefs.

Teachers' beliefs

There is no universally agreed definition of what beliefs actually are, making the study of teachers' beliefs problematic. As Pajares (1992) described the situation, "The difficulty in studying teachers' beliefs has been caused by definitional problems, poor conceptualizations, and differing understandings of beliefs and

belief structures" (p. 307). In this chapter, a "belief" is defined as anything a teacher regards as true, drawing on Ajzen and Fishbein (1980). One of the challenges involved in studying beliefs is separating them from knowledge. In a review of studies of teachers' beliefs related to mathematics education, Thompson (1992) described two characteristics of beliefs – their disputability and their ability to be held with different levels of conviction – that distinguish them from knowledge. In addition to issues of defining and operationalising teachers' beliefs, it must also be acknowledged that teachers' beliefs and practices are affected by the school environments in which they work (Nespor, 1984; Timperley & Robinson, 2001), therefore they cannot be isolated from their contexts.

The relationship between teachers' beliefs and the teaching of primary mathematics, in particular, has been the focus of a small number of studies. In a UK study, Askew, Rhodes, Brown, Wiliam, and Johnson (1997) examined primary teachers' beliefs related to three aspects of teaching numeracy: "beliefs about what it is to be a numerate pupil"; "beliefs about pupils and how they learn to become numerate"; and "beliefs about how best to teach pupils to become numerate" (p. 23). They sought to explicate associations between student achievement and the beliefs of effective teachers. The researchers elected to work in schools whose average students' achievement was above expectations, then asked senior management to indicate which teachers they believed were the most effective numeracy teachers. These teachers' students completed the same numeracy test on two occasions, approximately six months apart, to identify changes in their achievement, as an indicator of the teachers' effectiveness. Teachers' beliefs were categorised as tending towards one of three orientations: transmission, discovery, or connectionist. Central to connectionist beliefs is that "teaching mathematics is based on dialogue between teacher and pupils, so that teachers better understand the pupils' thinking and pupils can gain access to the teachers' mathematical knowledge" (p. 32). This is in contrast to transmission beliefs which are focused on teaching mathematics routines and procedures, and discovery beliefs that are aligned with notions of students "needing to be 'ready' before they can learn certain mathematical ideas" (p. 34). Data sources for the study included questionnaire responses from 90 teachers, at least two classroom observations of 33 teachers, and three interviews for each of 18 of these teachers. From these interviews, Askew et al. identified emerging themes from which they developed a further set of interview items for the remaining 15 teachers who had been observed. The teacher

data were then compared with student achievement data. The results indicated that teachers who were highly effective typically espoused connectionist beliefs, while those who were aligned more closely with transmission or discovery beliefs tended to be less effective.

Muijs and Reynolds (2002) built on Askew et al.'s (1997) study by using structural equation modelling to test hypothesised relationships between primary teachers' beliefs, behaviours, subject knowledge and self-efficacy, and student achievement, and found that connectionist beliefs "had a significant influence on achievement, through their impact on teacher behaviors, of which they were the strongest predictor" (p. 12). Relating this back to Bandura's (1978) triadic reciprocal causation, this is a further illustration of personal factors (teachers' connectionist beliefs) influencing teachers' behaviour, which then had an impact on student behaviour (mathematics achievement). However, as the authors point out, the teachers' subject-knowledge data were self-reported on both data-gathering occasions, and the sample of 103 teachers was fairly small. These two studies both identified that particular sets of beliefs are associated with students developing mathematical understanding – a goal of many recent mathematics education initiatives around the world.

Changing teachers' beliefs and practices

As more is learnt about what constitutes effective teaching in different subject areas, there are constant demands for primary teachers to modify their teaching practice. Teachers' beliefs strongly influence their teaching practice (Cohen & Ball, 1990; Nespor, 1987), so to make more than superficial changes to their practice requires changing their beliefs (Hirsch & Killion, 2009; Timperley, Wilson, Barrar, & Fung, 2007). Borko and Putnam (1996) proposed that it is critical that teachers' practices and beliefs both "become the object of reflection and scrutiny" (p. 702) in school improvement initiatives. Guskey (2002) maintained that teachers – quite reasonably – make enduring changes to their practice only after they have observed improvements in their student outcomes, on the basis of new practice (presumably).

Teachers' beliefs, however, are notoriously difficult to change (Lortie, 1975) and in the context of school improvement initiatives, "teachers' belief systems can be ignored only at the innovator's peril" (Clark & Peterson, 1986, p. 291). Furthermore, teachers'

interpretations of schooling improvement initiatives are coloured by their existing beliefs, making their beliefs resistant to change and affecting what teachers learn during professional development (Ball, 1996).

In this section, the focus is on studies that have investigated what is needed in order to change teachers' beliefs and practices. Lortie (1975) identified three inter-related teacher orientations – "presentism" ("concentrating on short-range outcomes as a source of gratification" (p. 212), rather than long-term goals), conservatism (loyalty to existing systems and methods) and individualism (preferring to work alone in the privacy of their classroom) – as potential impediments to teacher change. In a more recent study that drew on Lortie's research, Hargreaves and Shirley (2009) identified presentism as a theme in their data. Their study of teachers in over 300 secondary schools indicated that the teachers generally preferred strategies they could implement immediately, to working toward long-term goals.

In the late 1980s, according to Nespor (1987), little was known about how beliefs are established and how they can be changed. In a theoretical paper, Nespor (1987) took the position that a teacher's beliefs strongly influence their teaching practice, and that in order to reform classroom practices, there are essentially two options. The first is to:

> … routinize teaching to the extent that teachers could be taught recipe-like pedagogical methods, adherence to which could be closely monitored and regulated. That is, one could transform teaching into a set of well-defined tasks and thus reduce the role played by beliefs in defining and shaping tasks. (p. 326)

The second possibility, Nespor suggested, involves changing teachers' beliefs through a process of helping them to develop an awareness of their beliefs, before providing data that challenges these beliefs, and then presenting them with alternative beliefs. In contrast to this, Guskey (1986) had previously presented a model of the teacher change process that indicated that teachers' beliefs change only after their classroom practices and then students' achievement have both changed. Unlike Nespor's hypothesised process, Guskey's model included changes to teachers' beliefs at the end of the process, rather than the beginning.

Although some teachers might prefer practical changes to their practice that can be implemented with a minimum of delay, time is needed to effect deep and lasting change. As Dweck (2006) emphasised:

> Even when you change, the old beliefs aren't just removed like a worn-out hip or knee and replaced with better ones. Instead, the new beliefs take their place alongside the old ones, and as they become stronger, they give you a different way to think, feel, and act. (p. 208)

Guskey and Yoon's (2009) synthesis focussed on the effectiveness of teachers' professional learning in improving students' achievement and identified an association between the amount of time spent on professional learning and improvements in students' outcomes, suggesting that at least 30 hours of contact time can be needed for positive effects. Another important factor they identified was sustained follow-up that helps teachers to adapt recommended practices to their unique teaching situation. Stipek, Givvin, Salmon, and McGyvers (1998) also raised concerns about interventions that include insufficient training for teachers, and went so far as to suggest that interventions of short duration might actually have negative effects on student outcomes. As Guskey (2002) highlighted, professional development needs to be seen as an on-going process, rather than a one-off event, if it is to be effective.

Related to the time devoted to implementing and embedding an initiative, another factor that was identified in Hargreaves and Shirley's (2009) study as being likely to impede teacher change was teachers being expected to participate in too many reform initiatives. One effect of schools taking on multiple professional development foci over a school year was often to frustrate teachers as it did not allow them sufficient time to embed one initiative before they switched to a new focus (Education Review Office, 2009). This was supported by Hill, Hawk, and Taylor (2001), who looked at features of effective teacher development, and found that when schools restricted their professional development to one or two foci per year, teachers were more likely to be willing to try and make lasting changes. Similarly, in their synthesis of findings from investigations of professional learning and development for teachers, Timperley et al. (2007) highlighted teachers' in-depth learning being supported by school leaders rationalising competing demands to support.

Factors that can help to build connections between teachers' existing practices and the practices advocated in reforms have also been identified. In a national report on professional learning and development in New Zealand primary schools, the Education Review Office (2009) highlighted the inclusion of in-class support to help teachers adapt their new learning to their unique teaching context, as a feature of

effective facilitation. In a mathematics education context, in-class support has been a key feature of both the Numeracy Development Projects in New Zealand, and *Count Me In Too* (Department of Education and Training, NSW, 1998) in New South Wales. Timperley et al. (2007) also suggested that when substantive change is the goal, teachers need collegial support from others with whom they have a common sense of purpose. This support might be in the form of in-class support from facilitators or fellow teachers, working with a researcher, or participating in syndicate-wide or school-wide professional learning. Also described in the Education Review Office report was the importance of teachers' commitment to change, with the suggestion made that if teachers believe their existing practice is already effective, any initial enthusiasm is likely to quickly wane. Such an unwillingness to persevere to achieve long-term goals is an indication of presentism, and this apparent loyalty to existing practices indicates conservatism (Lortie, 1975). Collegial support and shared goals may help sustain a teacher's commitment to change.

Related to Lortie's (1975) teacher orientation of conservatism, Artigue and Perrin-Glorian (1991) suggested that when teachers are expected to adopt an innovative strategy they sometimes attempt to accommodate proposed changes within their usual way of functioning. Similarly, in their investigation of the effects of a 2-week professional development programme on the beliefs of eight middle-grades science teachers, Yerrick et al. (1996) found that the teachers chose to adopt components of reforms that they could assimilate into their practice. Both of these studies illustrate that conservatism can contribute to changing teachers' beliefs being a difficult process, especially when teachers are not provided with convincing evidence of the efficacy of proposed changes.

Marzano, Zaffron, Zraik, Robbins, and Yoon (1995) proposed that two types of change were made as the result of educational reform initiatives. What they termed *first order change* involved teachers assimilating new material and pedagogical techniques into their existing beliefs, and *second order change* actually altered teachers' beliefs. They suggested that the sustainability of innovations was largely determined by the success they had in changing teachers' beliefs. In the earlier quote from Nespor (1987), the point is made that, rather than attempting the difficult work of changing teachers' beliefs, an alternative might be for those leading teacher professional development to change teachers' practice at a surface level with "recipe-like pedagogical methods" (p. 326), resulting in what Marzano et al.

(1995) would call first order change. Timperley et al. (2007) also highlighted the possible tension between professional development providers working to change teachers' beliefs (second order change) when providers are also concerned with achieving implementation fidelity (first order change), especially in the case of professional development initiatives that are being implemented at scale. Indeed, if teachers' beliefs drive their practice, then demanding that teachers adopt alternative practices is unlikely to change their beliefs, and might result in poor implementation or open resistance to change. As Timperley et al. (2007) cautioned, "Addressing specific practices without attending to the beliefs that underpin them may be counter-productive" (p. 119).

In New Zealand, a particular set of teacher beliefs has been identified as negatively influencing the academic achievement of Māori and Pasifika students (Bishop, Berryman, Cavanagh, & Teddy, 2007). Bishop et al. found that the deficit beliefs of some teachers were associated with their believing that students' academic failure is caused solely by their family background and other external factors beyond teachers' influence. Other teachers acknowledged that family background does play a role in students' academic achievement, and took an agentic position where they attributed internal factors with greater influence on student achievement than external factors. Surmounting teachers' deficit theories on which some drew to explain the underachievement of Māori students in mainstream classes has been a focus of Te Kotahitanga, an evolving professional development intervention that sought to reduce disparities in the achievement of Māori students with that of non-Māori students. This innovation dealt with teachers' deficit beliefs by discursive repositioning that allowed teachers to take a more agentic position in relation to the achievement of Māori students. Fundamental to this innovation was challenging deficit theorising in a supportive way so that teachers became aware of their role in perpetuating power imbalances that positioned Māori students as failing at school, and were also provided with an alternative discursive position. Hui (meetings) for teachers, professional development facilitators, and members of the research team were often held at local marae (Māori meeting place), and were combined with in-class support to help teachers make this shift in their beliefs and practice. Using a pre-test at the start of the school year and post-test at the end, indicated that the mathematics progress of Year 9 and 10 Māori students whose teachers participated in this project was greater than the progress of students of non-participant teachers, and greater than the national norms for Māori students.

Another study that aimed to explicitly tackle teachers' deficit theorising about students' underachievement, this time in the context of literacy, included creating cognitive dissonance as an important feature (Timperley & Robinson, 2001). In the context of school improvement in teaching reading to students with low academic achievement, Timperley and Robinson investigated the processes involved in changing the beliefs of teachers in four primary schools. Participating schools drew their students from low socio-economic communities, and their students were predominantly Māori and Pasifika. In one school, Timperley and Robinson presented teachers with data on the skills their students had on school entry, which exceeded teachers' estimates of these students' skill levels. This meant that teachers could no longer explain students' poor achievement by claiming they were not ready to learn when they started school. Instead, teachers engaged in intensive professional development to focus on how they could improve their literacy teaching practices in order to cater for their students' identified learning needs. In another school, teachers attended an initial literacy professional development workshop, which prompted them to collect data on their junior students' letter-sound knowledge. In this school, too, students' skills were greater than teachers' perceptions. At the beginning and end of the professional development, teachers were asked to give three reasons for students achieving below curriculum expectations. At the conclusion of the development, 87% of the reasons given by teachers for students' achievement levels were school-based, compared to the same percentage being attributed to factors associated with students and their family backgrounds before the development began. Teachers' deficit theorising about the underlying causes of students' poor achievement made them inclined to "explain away" discrepant data, and to highlight "the occasional child who engaged in eating crayons" (p. 297) as more typical.

The models of teacher professional development described in both Timperley and Robinson (2001) and Bishop et al. (2007) included in-class support for individual teachers, as did the Numeracy Development Projects. In the USA, Kose and Lim (2010) surveyed 330 teachers in 25 elementary schools to identify relationships between teachers' beliefs and transformative professional development that was delivered in the form of workshops, conferences and academic study. They found that deficit thinking was difficult to overcome with these modes of professional development, and suggested that on-going, school-based learning would increase the effectiveness of such initiatives. Clearly, deficit beliefs that impact negatively on

the achievement of traditionally marginalised groups of students need to be re-framed so that teachers acknowledge the difficulties students face, and take responsibility for the achievement of all students.

In a synthesis of studies that included some of the New Zealand research described here, Alton-Lee (2003) underscored the importance of teachers having high expectations for students' learning as a factor that contributes to one of ten characteristics of quality teaching that could improve achievement for New Zealand's diverse student population. One of the studies illustrated this point in the context of the teaching of early literacy skills to Māori and Pasifika students (Phillips, McNaughton & MacDonald, 2001), and found that addressing teachers' low expectations for students' learning impacted positively on students' achievement in reading.

The mathematics context

Investigations of how primary teachers' beliefs about teaching mathematics have changed during their involvement in mathematics reforms (Spillane, 1999; Vacc, Bright, & Bowman, 1998) are few. In the context of the Numeracy Development Projects, some anecdotal evidence of changes in teachers' beliefs has been reported (for example, Higgins, 2002; Trinick, 2005), and changes in teachers' attitudes to teaching mathematics have been explored (Higgins, 2002; Thomas & Ward, 2002), but no studies specifically aimed to investigate changes in teachers' beliefs.

Vacc et al. (1998) examined the changes in beliefs of 19 teachers during 2 years of the Cognitively Guided Instruction (Carpenter, Fennema, Peterson, & Carey, 1988) professional development programme in North Carolina. The participants were drawn from five teams that worked with teacher educators in the programme which emphasised a problem-solving approach to teaching mathematics, and catering for the learning needs of individual students. In addition to attending after-school workshops, teachers received regular in-class support. A content analysis of teachers' responses to three open-ended questions that aimed to identify their beliefs about teaching and learning mathematics, administered on three occasions, revealed mixed results. On the one hand, at the end of the 2 years around three-quarters of the teachers were advocates for teaching mathematics through a problem-solving approach. On the other hand, though, 42% of the teachers still did

not appear to believe there was a need to plan instruction to target individual needs. Earlier research (Fennema et al., 1996) found that even after 4 years' participation in the same professional development programme, there seemed to be no substantial changes to some teachers' beliefs. Because student achievement measures were not included in this study, no conclusions can be drawn about the effect of reported changes – or a lack thereof – in teachers' beliefs on student outcomes.

Based on findings of a mixed-methods study, Spillane (1999) proposed a model to explain how teachers had responded to a mathematics reform in the US, in which teachers' beliefs, knowledge and dispositions mediated the opportunities with which teachers were presented to learn and change. Teachers who had substantially changed their practice were compared with teachers who had not, in terms of their "zones of enactment" – essentially, the various situations in which a teacher makes sense of, and operationalises, reform initiatives. Teachers who had made substantial changes to their practice, Spillane found, were more likely to have enactment zones that extended beyond their classrooms and included networks of practice in which teachers had rich discussions about the implementation of reforms' recommendations with teaching colleagues, as well as outside experts.

Beswick (2007/2008) described the effects on 22 teachers, 13 of whom were primary teachers and nine secondary, of a professional learning programme that aimed to more closely align teachers' beliefs about students generally with their beliefs about students who had mathematics learning difficulties. To identify their beliefs and attitudes in relation to students with mathematics learning difficulties, teachers completed a questionnaire before and after three 3-hour workshops that focused on effective strategies for numeracy teaching and an inclusive approach to teaching. Teachers' initial responses indicated that they did hold different beliefs about numeracy teaching, depending on a student's perceived ability to learn mathematics. Although at post-test there was evidence that some teachers had changed their beliefs in relation to their academic expectations for students with mathematics learning disabilities, the item on which there was the least change in teachers' responses, with more than half of the teachers still agreeing, was, "Some people have a maths mind and some don't" (p. 12). Although this was interpreted by Beswick as suggesting "an underlying tendency of teachers to cite the cause of students' difficulties beyond the influence of teaching" (p. 13), it might reflect teachers' belief in a predisposition to learn mathematics rather than their belief that

they cannot influence students' achievement in mathematics. Future research that makes connections between teachers' reported changes in beliefs, their classroom practices, and changes in their students' achievement, and that assesses these changes over time, would build on the findings from the studies presented here.

Teacher self-efficacy

Bandura's (1986) definition of self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391) was used to shape interpretation of teachers' self-efficacy in this research, as it was for students' mathematics self-efficacy. However, teacher self-efficacy (for teaching mathematics) differs from student self-efficacy (for doing mathematics) in the ways it has been operationalised by researchers. To measure students' mathematics self-efficacy with a high degree of specificity, identical sets of mathematics problems can be used with students of similar age, across different schools. To measure teacher self-efficacy on an equally specific basis, which can also be used across a range of schools, is problematic. This is because, for teacher self-efficacy to be operationalised at the same level of specificity, teachers would be required to make self-efficacy judgments in relation to their ability to undertake specific teaching activities for particular students, which teachers would subsequently be required to undertake. It is the inclusion of *particular students* that makes a uniform measurement difficult.

Teachers' self-efficacy is context specific, but – as was the case with students' self-efficacy – the level of specificity of the context has varied across studies. Some researchers have chosen a broad context of teaching in general (Caprara, Barbaranelli, Steca, & Malone, 2006; Friedman & Kass, 2002; Gibson & Dembo, 1984; Guskey & Passaro, 1994; Midgley et al., 1989; Woolfolk & Hoy, 1990). Others have opted for a subject-specific focus – in this instance, mathematics (Midgley et al, 1989; Philippou & Christou, 2002; Puchner & Taylor, 2006; Ross & Bruce, 2007) – or an area of teaching such as students with special needs (Brady & Woolfson, 2008). Others have narrowed the focus still further to particular domains within a subject (for example, Rubeck and Encohs (1991) investigated teachers' self-efficacy for teaching chemistry, as distinct from their self-efficacy for teaching science).

Teachers' self-efficacy functions in a similar fashion to students' self-efficacy; in both cases, it is mastery experiences that are the most powerful source of efficacy information. A teacher is likely to think they have performed well when they see evidence of their students making progress in their learning, and this success feeds their self-efficacy (Dellinger, Bobbett, Olivier, & Ellett, 2008), motivating them to maintain their effort and persist to achieve their goals, resulting in a snowball effect. A teacher with strong self-efficacy is also likely to influence student achievement by showing greater perseverance when teaching a student who is struggling (Gibson & Dembo, 1984). So teachers' and students' self-efficacy are to some degree interdependent. Two studies have concluded that teachers with strong self-efficacy are often more receptive to innovative approaches and are more inclined to value and implement these (Evers, Brouwers, & Tomic, 2002; DeForest & Hughes, 1992), suggesting that teachers with high self-efficacy levels are likely to show less conservatism than teachers with weak self-efficacy.

Developing these ideas further, other studies (such as Goddard, Hoy, & Woolfolk Hoy, 2000, 2004) have explored the effect of collective efficacy, which they explained is more than the sum of the efficacy beliefs of individual teachers in a school. Instead, it represents "the group's shared belief in its conjoint capabilities to organize and execute courses of action required to produce given levels of attainments" (Bandura, 1997, p. 477). In Bandura's (1993) study, teachers' perceived collective efficacy for promoting students' academic progress in mathematics and reading was investigated. The findings indicated that factors such as student transience and absenteeism, and their families' socioeconomic levels were associated with a school's collective efficacy. Although in New Zealand the role of teachers' collective efficacy has been acknowledged in reports of studies that have focused on raising the achievement of Māori and Pasifika students (for example, Phillips et al., 2001), it has not actually been measured, or discussed in relation to their findings. Whether there might be an association between changes in teachers' deficit beliefs about students' poor achievement, teachers' collective efficacy, and – most importantly – students' achievement, remains to be investigated.

An ill-defined construct

For the last three decades, confusion about the meaning of the terms *teacher efficacy, teacher sense of efficacy,* and *teacher self-efficacy* has abounded in the research literature and various definitions have been proffered with the result that teacher self-efficacy remains ill-defined. This section outlines the development of teacher self-efficacy measures since the 1970s to help identify where the misconstructions began. In an effort to avoid misrepresenting the construct of "teacher self-efficacy", the exact labels researchers used for the constructs they claim to have measured are indicated by italics.

In early studies (Armor et al., 1976; Berman & McLaughlin, 1977) that included a measure of what was referred to as a teacher's *sense of efficacy*, just two items were used, drawn from Rotter's (1966) locus of control construct. Because both studies were funded by the Rand Corporation, these items have often been referred to in the literature as the "Rand items" (for example, Woolfolk & Hoy, 1990). Subsequently described as measuring teachers' self-efficacy in relation to internal and external influences respectively, these items were:

- If I try really hard, I can get through to even the most difficult or unmotivated students

- When it comes right down to it, a teacher really can't do much (because) most of a student's motivation and performance depends on his or her home environment. (Armor et al., 1976, p. 23)

A number of subsequent studies included one or both Rand items (Gibson & Dembo, 1984; Guskey & Passaro, 1994; Midgley et al., 1989; Woolfolk & Hoy, 1990). Building on these two items, Gibson and Dembo (1984) developed and statistically tested what was to become the first widely-used instrument that measured *teacher efficacy*. Sixteen of the 30 items on their initial Teacher Efficacy Scale loaded on two independent factors, thought to represent two dimensions of teacher efficacy:

- Personal teaching efficacy – "belief that one has the skills and abilities to bring about student learning" (Gibson & Dembo, 1984, p. 573). An example of a personal teaching efficacy item is: "When I try really hard, I can get through to most difficult students" (p. 573), very similar to the first Rand item, above; and

- Teaching efficacy, relating to teaching more generally. An example of a teaching efficacy item is: "The amount a student can learn is primarily related to family background" (p. 573), similar to the second Rand item.

Items from Gibson and Dembo's scale were subsequently used in a number of studies (Anderson, Greene, & Loewen, 1988; Guskey & Passaro, 1994; Philippou & Christou, 2002; Ross, 1992; Woolfolk & Hoy, 1990).

Guskey and Passaro (1994) supported the two-dimensional nature of teacher efficacy, but with an interpretation that reflected Rotter's (1966) locus of control, from which the Rand items were originally developed. Guskey and Passaro maintained that the two factors that resulted from their factor analysis of items adapted from Gibson and Dembo's (1984) instrument were not personal and general teaching efficacy, but were distinguished by whether teachers attributed influences to internal or external causes. They claimed that personal teaching efficacy represented (internal) personal influence, and general teaching efficacy comprised teachers' beliefs about (external) influences outside the classroom, such as students' background. At this point, it appears that interpretations of efficacy items had come full circle. This interpretation was later supported by Philippou and Christou (2002) in their study of primary teachers' mathematics *teaching efficacy beliefs*.

Bandura's seminal paper expounding self-efficacy theory was published in 1977, after the publication of Amor et al.'s (1976) study, and within a month of Berman and McLaughlin's (1977) (Rand) work. Looking back over the development of teacher self-efficacy measures, it seems reasonable to suggest that the two Rand items were not developed with self-efficacy theory in mind. Items that were originally designed to indicate a teacher's beliefs about locus of control were embraced by researchers as measuring teachers' efficacy. This appears to be the point from which much of the confusion about teachers' self-efficacy stems. After these early measures had established a foothold, Bandura's (1977b) work was used to support studies claiming to measure *teachers' self-efficacy* (and *teacher efficacy*, and *teachers' sense of efficacy*).

Tschannen-Moran, Woolfolk Hoy, and Hoy's (1998) theoretical paper presented the two Rand items along with items from Gibson and Dembo (1984) in an instrument intended to measure *teacher efficacy*, which they defined as "… the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233). Their definition was very close to Bandura's, although seems to represent a lesser degree of specificity than that intended by Bandura (1986). Tschannen-Moran et al.'s definition has been cited by other researchers as "the prevailing conception of

teacher efficacy" (Ross & Bruce, 2007, p. 53). The items that Tschannen-Moran et al. (1998) compiled have subsequently been adopted – or adapted – for use in other studies (for example, Brady & Woolfson, 2008; Caprara et al., 2006). As with most teacher self-efficacy assessments, teachers are asked to show how much they agree with statements, using Likert-type scales of five or six points. Although Tschannen-Moran et al.'s (1998) definition of *teacher efficacy* was fairly consistent with Bandura's definition, their items did not operationalise self-efficacy at a similar level of specificity as students' mathematics self-efficacy has been operationalised.

To try to address the issue of specificity, Dellinger et al. (2008) developed an alternative *teacher self-efficacy beliefs* instrument – the Teachers' Efficacy Beliefs System–Self Form – which they designed to be more closely related to the classroom context. They also intended their conceptualisation of teacher self-efficacy to more closely adhere to Bandura's (1986) definition of self-efficacy. Dellinger et al. (2008) defined *teacher efficacy* as "focused on successfully affecting student performance" (p. 753), and *teacher self-efficacy* as "a teacher's individual beliefs in their capabilities to perform specific teaching tasks at a specified level of quality in a specified situation" (p. 752), neither of which include "for a specific student" as part of the definition, although it is perhaps implied in the latter. They explained that the former is thought to be based on outcome expectancies, while the latter relates to behaviours that should help achieve the expected outcomes, and is aligned with Bandura's definition (see *Teacher self-efficacy,* above). Dellinger et al.'s questionnaire, tested with a large sample of 2,373 elementary school teachers, asked them to respond to items that shared the common stem, "Right now in my present teaching situation, the strength of my personal beliefs in my capabilities to…", such as "plan activities that accommodate the range of individual differences among my students" (p. 764). The 1-4 Likert-type scale ranged from 1, *Weak beliefs in my capabilities* to 4, *Very strong beliefs in my capabilities*. Although Dellinger et al. (2008) used items that asked teachers to make self-efficacy judgments in relation to their "present teaching situation", this still meant that elementary teachers (who are not generally subject specialists) had to amalgamate their self-efficacy judgments of teaching across a variety of subject areas, and with a variety of students.

Three studies (Evers et al., 2002; Friedman & Kass, 2002; Tschannen-Moran & Woolfolk Hoy, 2001) have included reports of an analysis of the factor structure of their various interpretations of teacher self-efficacy since Gibson and Dembo's

(1984) early construct validation study. Fairly recently, Fives and Buehl (2010) conducted such an analysis of Tschannen-Moran and Woolfolk Hoy's (2001) Teachers' Sense of Efficacy Scale, a later version of their 1998 questionnaire. For practising teachers, they identified three distinct factors: "efficacy for classroom management, instructional practices, and student engagement" (p. 118). When this structure was applied to data from pre-service teachers, however, items loaded on more than one factor and theoretically meaningful interpretation was not possible. Fives and Buehl suggested that the self-efficacy of pre-service teachers is less clearly differentiated that that of more experienced teachers.

Teacher self-efficacy for teaching mathematics

Narrowing the focus further, empirical studies that have investigated primary teachers' self-efficacy for teaching mathematics, specifically, might define teacher self-efficacy as *a teacher's judgments of their capabilities to organise and execute effectively, a particular mathematics teaching activity for a specific student*, consistent with Bandura's (1986) definition of self-efficacy. In three of the four relevant studies located, the research was conducted over the last decade, with generalist primary teachers.

The single study that was undertaken over 20 years ago, and that included specialist mathematics teachers as well as generalist teachers who taught mathematics, was Midgley, Feldlaufer, and Eccles's (1988, 1989) longitudinal study, that investigated the relationship between teachers' self-efficacy and students' beliefs in mathematics, over the transition to junior high school. Four waves of data were collected over 2 years – students' final year at elementary school and their first year at junior high school. Data comprised students' performance on a statewide mathematics test, a student questionnaire about their mathematics-related beliefs, and a teacher efficacy questionnaire that included one of the Rand items. Midgley et al. (1989) found that:

> Generally, the beliefs of students who had low-efficacy teachers became more negative as the school years progressed, whereas the beliefs of students who had high-efficacy teachers became more positive or showed less negative change from the beginning to the end of the school years. (p. 254)

More than a decade later, Philippou and Christou (2002) used an instrument developed from Gibson and Dembo's (1984) items to measure 157 primary teachers' *personal teacher efficacy* and their *general teaching efficacy*, which they

collectively termed teachers' *efficacy beliefs* (p. 211). Personal teaching efficacy was assessed using items such as, "I can teach successfully and achieve good results, even in mathematical topics considered difficult", and general teaching efficacy with items such as, "Taking into account all factors influencing mathematics learning, then the possibilities of the teacher are very limited" (pp. 222-3). They also conducted semi-structured interviews with 18 respondents at different stages in their teaching careers to help identify how efficacy beliefs might change over time, and also how particular pre-service training courses whose graduates teach in Cyprus schools might have been associated with this. Their findings indicated that teachers' level of efficacy for teaching mathematics tended to decrease early in their careers, and then to increase. Longitudinal studies are needed to give a more reliable picture of what happens over time to individual teachers' levels of self-efficacy for teaching mathematics.

Puchner and Taylor (2006) explored *teacher efficacy* in the context of mathematics lesson study groups, with eight teachers divided evenly among two groups. Qualitative data from the researchers' participant observations of the groups' meetings was triangulated with interviews with individual teachers, and documents that were collected. Their findings suggested that the teachers' collaboration in lesson study groups increased their self-efficacy for teaching mathematics as the teachers developed greater awareness of the impact on students' engagement made by their planning. Puchner and Taylor stated that "teacher efficacy can be defined as a teacher's judgment of their ability to bring about student learning or development" (p. 925). This definition focuses on the expected outcome of a teacher's behaviour – student learning – rather than their "capabilities to organize and execute courses of action required" (Bandura, 1986, p. 391), and also omits "for a specific student", and therefore is not consistent with the definition used in the present study.

Ross and Bruce (2007) assessed the *teacher efficacy* of 106 Grade 6 teachers in one Canadian district, in their experimental study. Over a 3-month period, teachers in the treatment group participated in professional development that was intended to increase their teacher efficacy. Tschannen-Moran and Woolfolk Hoy's (2001) *teacher efficacy* items were adapted for a mathematics context by adding the words "in mathematics" to existing items. Thus, "How much can you do to motivate students who show low interest in schoolwork?" (Tschannen-Moran & Woolfolk Hoy, 2001, p. 800) became, "How much can you do to motivate students who show

low interest in mathematics?" (Ross & Bruce, 2007, p. 55). These modifications narrowed the teacher self-efficacy focus to a mathematics context. In both these studies, rather than the items being statements with which teachers were asked to indicate their level of agreement, items were phrased as questions to which teachers responded using a 4-point scale: *not at all, somewhat, important,* or *critical* (Tschannen-Moran & Woolfolk Hoy, 2001), or a 5-point scale: with anchors *nothing* and *a great deal* (Ross & Bruce, 2007). Ross and Bruce conducted a factor analysis of teachers' responses to their mathematics-specific items, and identified three factors that they interpreted to represent three sub-categories of "teacher efficacy": 1) "efficacy for engagement"; 2) "efficacy for teaching strategies"; and 3) "efficacy for student management" (p. 53). These were the same three factors identified in Tschannen-Moran and Woolfolk Hoy (2001).

Ross and Bruce's (2007) data analysis indicated that only in *efficacy for student management* did the treatment teachers report significantly higher efficacy levels than teachers in the control group. Furthermore, like Puchner and Taylor (2006), Ross and Bruce (2007) adopted a definition that reflected an outcome expectancy rather than self-efficacy: "*Teacher efficacy* is a teacher's expectation that he or she will be able to bring about student learning" (p. 50, italics in original). Again, this interpretation is not consistent with Bandura's (1986) definition that was adopted in the present study.

Only a small number of studies have focused on primary teachers' self-efficacy for teaching mathematics, and their interpretations have varied in perhaps subtle, and certainly important, ways. The only intervention study that aimed to increase teachers' self-efficacy for teaching mathematics (Ross & Bruce, 2007) reported fairly weak results. Just one study (Midgley et al., 1989) assessed teachers' self-efficacy for teaching mathematics over a time-frame that exceeded 4 months. Further investigations are needed that explore how teachers' self-efficacy for teaching mathematics might be influenced by interventions, and how this belief changes over the course of time.

Teachers' beliefs about intelligence

> Thus, teachers who see student achievement in school as something that can be cultivated, *through effort*, also believe in their own ability to help their students make progress, and thus to play a determining role in their students' academic success. (Leroy, Bressoux, Sarrazin, & Trouilloud, 2007, p. 539)

Midgley et al. (1988) identified an association between teachers' entity theory-of-intelligence and their need for control. This was investigated further in Leroy et al.'s (2007) study, which investigated the roles played by particular teacher beliefs in establishing an autonomy-supportive climate in their classrooms. They measured the *teacher efficacy*, theory-of-intelligence, and perceived work pressures of 336 fifth-grade teachers in France, and used path analysis to identify the respective roles of these factors. Their findings indicated that a climate that supported students' autonomy was indirectly associated with teachers having an incremental theory-of-intelligence because this belief tended to be related to high levels of teacher efficacy. They did not, however, find any association between an entity belief and self-efficacy level.

Leroy et el.'s (2007) findings are consistent with those of Askew et al.'s (1997) study, in which a transmission orientation to teaching mathematics was characterised by prioritising teaching over learning, and basing teaching on teachers explaining their methods to students. Students' autonomy was not a goal for a teacher with this orientation. Whether or not a transmission orientation might be associated with an entity theory-of-intelligence has not yet been explicitly investigated.

Teachers' beliefs about ability have also been explored in the context of their beliefs about the ability to teach. In Fives and Buehl's (2008) two-part exploratory investigation, the degree to which pre-service and practising teachers believed that "some people are *born teachers*" was examined. Open-ended questionnaire items were given to pre-service and practising teachers who were enrolled in a university course. No comment was made regarding whether the responses of pre-service and practising teachers varied. Themes were generated from their responses, and these were developed into questionnaire items that required responses on Likert-type scales, for validating in the second part of the study with 351 pre-service teachers. The final Teaching Ability Belief Scale comprised 28 items, such as "*Individuals are born with the ability to teach*" and *"Teaching is a learned activity*" (p. 161). Those who indicated a belief that teaching ability is innate tended to rate

the importance of teaching strategies and instructional practices more highly than pedagogical content knowledge and knowledge of theory, which were rated more highly by those who believed teaching ability is learned.

In a mathematics context, Stipek, Givvin, Salmon, and MacGyvers (2001) hypothesised that more traditional beliefs about teaching and learning that focus on the importance of correct answers, rather than the current emphasis on developing students' understanding of mathematics, would be associated with an entity theory-of-intelligence. Their study involved 21 fourth to sixth-grade teachers and their 437 students, all of whom completed questionnaires at the start and end of a school year to identify their beliefs. In addition, videotapes were made of at least two lessons for each teacher, from which their teaching practices were later coded. The multiple data sources allowed the comparison of teachers' beliefs and practices. The results showed that teachers' beliefs were very similar on both occasions, and that sets of beliefs tended to cluster together. So a teacher who believed that students' goals should be to learn procedures so that they can produce correct answers, and that the teacher should be in complete control of mathematics activities, tended to also perceive mathematics ability to be fixed. On the other hand, a teacher who believed mathematics ability can develop was also likely to believe that students' goal is to develop understanding, and that students should be encouraged to have some autonomy. Associations between teachers' reported beliefs and observed practices were evident, with those who indicated traditional beliefs also demonstrating traditional practices in the classroom – emphasising correct answers and speed, and "[maintaining] a social context in which mistakes were something to be avoided" (p. 223).

In a review of studies investigating children's theory-of-intelligence, Dweck and Bempechat (1983) claimed that a teacher with an entity theory-of-intelligence is likely to attribute a student's poor progress to the students' limited, fixed intelligence and to factors beyond their control such as a student's home background, and to show less effort and persistence with helping this student learn, and is likely to give up on such "hopeless" cases. In contrast, they said, a teacher with an incremental theory-of-intelligence is more likely to believe that each student is capable of learning, that it is their responsibility to ensure that learning occurs, and that through effort and persistence they can achieve this. However, no teacher data were presented to support any of these claims.

Looking beyond individual teachers' beliefs, Murphy and Dweck (2010) have suggested that an organisation might essentially have its own collective theory-of-intelligence that results in its employees presenting themselves as matching the dominant belief. They claimed that their four related studies with 242 university students indicated that "people systematically shift their self-presentations when motivated to join an entity or incremental organization" (p. 283). However, changing the way a person presents themselves to others does not necessarily equate with a change of beliefs – about intelligence, or anything else.

Associations between teachers' and students' beliefs, and students' mathematics achievement

Teachers' beliefs can be mirrored to some degree in their students. For instance, Stipek et al. (2001) found that "teachers' self-confidence as mathematics teachers was significantly correlated with students' perceptions of their own competence as mathematics learners" (p. 224). No studies were found that presented evidence for a similar relationship between teachers' theory-of-intelligence and that of their students. Neither have empirical studies explored the possibility of an association between primary teachers' beliefs about intelligence and students' achievement in mathematics.

The relationship between teachers' self-efficacy beliefs and those of their students is also a little-researched area. Anderson et al. (1988) reported that students' self-efficacy beliefs were positively correlated with their teachers' self-efficacy, with more statistically significant correlations at Grade 3 than Grade 6. However, the student self-efficacy measures comprised four modified Rand items, such as "Most kids can do well in school if they work and study hard" and "When I really try hard I get good grades in school" (p. 151).These items are not consistent with Bandura's (1986) recommendation that self-efficacy judgments should be task-specific, therefore the relationship between teachers' and students' self-efficacy beliefs needs further empirical testing.

Only Gibson and Dembo (1984) have investigated how elementary school teachers' self-efficacy was associated with their instructional practices. They found that teachers with high self-efficacy levels tended to spend more time on students' academic learning, including the provision of support for students with particular learning difficulties, than teachers with low levels of self-efficacy, who instead

focussed more on non-academic activities, and typically did not persevere with students who found learning difficult. Although the characteristics associated with different self-efficacy levels seem likely to affect students' achievement, there was no empirical evidence available to support this.

Communicating teachers' beliefs to students: Teacher-student feedback

One of the most explicit ways in which teachers' beliefs are communicated to students – teacher-student feedback – has the potential to be pivotal where building students' mathematics self-efficacy and incremental beliefs about intelligence is the goal. This section will outline the role played by *teacher-student feedback* – broadly defined here as verbal interaction that focuses on the student's progress towards their learning goals – in the relationships between the teachers' and students' beliefs and students' achievement in mathematics.

Although student-student interactions are also an important element of numeracy discourse, the focus of the present study was on teacher-student formative feedback as a means of shaping students' beliefs about intelligence and self-efficacy. This is consistent with evidence that effective feedback can be one of the greatest influences on students' learning (Alton-Lee, 2003). Information included in feedback needs to be used by students in order for it to be considered formative (Black & Wiliam, 1998). Some of the key studies in the area of teacher-student feedback are presented next.

In a year-long study (Tunstall & Gipps, 1996a, 1996b) that explored students' and teachers' perceptions of teacher-student feedback as a means of formative feedback, interviews were conducted with 49 six and 7-year-olds and eight teachers in six schools. Over the course of a school year, between 24 and 36 hours of classroom observations and tape-recording of classroom dialogue were also made for each teacher, providing a substantial data collection from which to develop their grounded typology of teacher-student feedback (see Figure 4.1). They found that "every teacher observed used each type of feedback at some point, although individuals had particular styles" (1996a, p. 402) and that all feedback types occurred in all subjects. Furthermore, examples of each feedback type were evident in students' feedback descriptions (1996b).

<table>
<tr><td colspan="4">Positive feedback …….……..…….…… Achievement feedback</td></tr>
<tr><td colspan="2">Evaluative feedback</td><td colspan="2">Descriptive feedback</td></tr>
<tr><td>Type A</td><td>Type B</td><td>Type C</td><td>Type D</td></tr>
<tr><td>Rewarding
Rewards</td><td>Approving
Positive personal expression; general praise; warm expression of feeling; positive non-verbal feedback.</td><td>Specifying attainment
Specific acknowledgement of attainment; use of criteria in relation to work/behaviour; more specific praise.</td><td>Constructing achievement
Mutual articulation of achievement; praise integral to description.</td></tr>
<tr><td>Punishing
Punishments</td><td>Disapproving
Negative personal expression; reprimands; negative generalisations; negative non-verbal feedback.</td><td>Specifying improvement
Correction of errors; more practice given.</td><td>Constructing the way forward
Mutual critical appraisal; provision of strategies.</td></tr>
<tr><td colspan="2">Evaluative feedback</td><td colspan="2">Descriptive feedback</td></tr>
<tr><td colspan="4">Negative feedback ……..……. Improvement feedback</td></tr>
</table>

Figure 4.1. Tunstall and Gipps (1996a) typology of teacher feedback.

Tunstall and Gipps made connections between their findings and previous work on achievement goal theory, synthesised in Ames' (1992) theoretical paper. Ames proposed that different classroom learning environments lead to different goal orientations in students, and Tunstall and Gipps (1996a) suggested that teachers' feedback to students was a feature of the classroom environment that would affect students' goals. From their findings, Tunstall and Gipps (1996a) hypothesised that Feedback Types A and B "can lead to a performance-goal orientation". Feedback Type C, on the other hand, "can lead to a mastery goal orientation". They described Type D feedback as "learning-oriented in that it includes many of the strategies described in constructivist approaches to learning", and emphasised that "both types C and D are crucial to pupils' learning" (p. 403). Concluding their 1996b paper, Tunstall and Gipps argued that "*all* learners of whatever age need the same support: praise and reward linked with the recognition of competence, together with the provision of strategies for developing critical appraisal" (p. 202, italics in original). Their aim was to develop a framework for teachers to use to analyse their practice, rather than to identify relationships between particular types of feedback and student achievement.

In New Zealand, feedback has been emphasised as an important component of quality teaching (Alton-Lee, 2003: Hattie, 1999; Hattie & Timperley, 2007). Regarding the relationship between teacher feedback and student achievement, Hattie (1999) suggested that:

> The most powerful single moderator that enhances achievement is feedback. The simplest prescription for improving education must be "dollops of feedback" – providing information how and why the child understands and misunderstands, and what directions the student must take to improve. (p. 11)

Hattie stressed the importance of feedback that bridges the gap between a student's current achievement and the student's learning goal, informing the student of what they need to do in order to reach that point. The exact nature of feedback that can foster students' mathematics self-efficacy remains uncertain, and Hattie and Timperley (2007) described the many factors that a teacher must consider in order to give feedback that supports students' self-efficacy, for example, "having exquisite timing to provide feedback before frustration takes over" (p. 103). They suggest that in order to make effective feedback the teacher's focus, other aspects of the classroom programme must be securely established and operate with a minimum of teacher attention.

In the context of the Numeracy Development Projects, Knight (2003) investigated the feedback given by six primary teachers to their students during numeracy lessons, and categorised the feedback according to Tunstall and Gipps' (1996a) typology. Of the 349 instances of oral feedback to students, only 17 per cent was descriptive, and no examples were categorised as *Constructing the way forward* in Type D. Knight concluded that with 74 per cent of feedback instances being coded as *Approving* Type B feedback, "Many valuable learning opportunities seemed to be being lost in the desire to be positive" (p. 44).

Teacher-student feedback plays a central role in building students' self-efficacy (Schunk & Zimmerman, 1997), although the features of such feedback continue to be the focus of debate. In their exploration of motivation and affect in senior primary mathematics classes, Schweinle et al. (2006) reported that "When feedback was frequent, elaborative, positive, and used to help students develop understanding, … students reported higher affect, efficacy, and importance" (p. 288). Schunk (1982) reported that effort-attributional feedback raised students' self-efficacy and positively affected performance, but in another study (1983b) reported that ability-

attributional feedback had a greater impact on both self-efficacy and performance. Schunk's (1984) pair of experimental studies further explored the effects of different combinations of effort- and ability-attributional feedback on 80 primary students' mathematics self-efficacy, over four sessions. The findings of both studies indicated that students who received ability-focused feedback in the first two sessions had higher mathematics self-efficacy and higher subtraction achievement at the studies' end, regardless of whether the feedback in the last two sessions focused on effort or ability. The students in Schunk's studies, however, were all students who were having difficulties learning mathematics, so to be praised for their ability in this domain might have had a greater positive effect than it might with all students.

A teacher's theory-of-intelligence seems likely to shape the feedback they tend to give students, which in turn might influence students' beliefs about intelligence. According to Black and Wiliam's (1998) review, the feedback teachers give students can be powerful because students' self-perception is "strongly influenced by teachers' beliefs about the relative importance of 'effort' as against 'ability'" (p. 24). Dweck (2000) argued that only feedback related to students' effort and strategy use will support an incremental theory-of-intelligence. Even if a teacher were to have a formula for effective feedback, Dweck cautioned that the ways a teacher interacts with students may be governed by the teacher's beliefs about intelligence; a teacher with an entity belief, for instance, might favour students they perceive to have greater ability.

Black and Wiliam (1998) interpreted Tunstall and Gipps' (1996a) typology as "a spectrum, ranging from those that direct attention to the task and to learning methods, to those which direct attention to the self" (p. 49) – the former having more positive effects on students' performance. This is consistent with Dweck's (2000) claim that feedback that focuses on effort and strategies can support an incremental theory-of-intelligence in students. However, Schunk's (1983, 1984) studies found that feedback that directed students' attention to their ability had a positive effect on the mathematics self-efficacy and achievement of students who had experienced difficulties learning subtraction, suggesting that the type of feedback that has the most positive effect is likely to vary for different students. What is unclear is the exact nature of teacher-student feedback that has the most positive effects on the achievement of the diversity of students in a typical primary classroom.

Chapter summary

Teachers' beliefs are resistant to change, making it difficult to effect deep and lasting changes to their practice. Considerable time is needed to change teachers' beliefs, which in turn guide their teaching practice and influence students' beliefs and mathematics achievement. Teacher orientations of presentism, conservatism, and individualism can hinder change in teachers' beliefs and practices beyond short-term, surface-level change. The inclusion of in-class support for teachers seems to be associated with initiatives that effect deep and lasting change. Presenting teachers with sound evidence that is dissonant with their existing beliefs provides teachers with a reasonable basis for reconsidering what they believe and why, and entertaining alternative perspectives.

The research methods used in the studies of teachers' beliefs reviewed here were much more varied than those used to investigate students' mathematics self-efficacy and theory-of-intelligence, with mixed methods more widely used with teachers. In the literature, teachers' self-efficacy has been represented in a variety of ways, which has made interpretation of the collective findings difficult. In the present study, a teacher's self-efficacy for teaching mathematics is defined as *a teacher's judgment of their capability to organise and execute effective mathematics teaching activities.* Tschannen-Moran et al. (1998) encouraged researchers to include qualitative methods in their studies of teacher efficacy, as "Interviews and observational data can provide a thick, rich description of the growth of teacher efficacy" (p. 242). Experimental or intervention studies that have explored possibilities for changing primary teachers' beliefs that relate to their mathematics teaching were relatively scarce, probably because teachers' beliefs are notoriously difficult to change.

Teachers' beliefs about teaching and learning are conveyed to their students via teacher-student feedback, which appears to have the potential to help shape students' beliefs about intelligence and their mathematics self-efficacy, and therefore might also be associated with students' mathematics achievement. In the present study, teachers' theory-of-intelligence was assessed so that associations with the beliefs and achievement of their students could be investigated. Although changing teachers' beliefs was not an explicit aim of this study, it was an implicit aim of the interventions.

Research questions and hypotheses

The main purpose of the present study was to investigate the effects on students' mathematics self-efficacy, theory-of-intelligence, and mathematics achievement of two sequential interventions over a 14-month period. A secondary purpose was to scrutinise Dweck's notion of theory-of-intelligence by checking students' responses to her six questionnaire items for convergence with their definitions of intelligence, described during interviews. Each participating school was allocated to one of three groups: the Control group, the Mathematics self-efficacy intervention group, or the Combined mathematics self-efficacy and theory-of-intelligence interventions group (also referred to as the Combined interventions group).

The main research question relating to student outcomes was:

> *Over the three data collection points, do individual student differences in mathematics self-efficacy, achievement, and theory-of-intelligence vary as a function of treatment group?*

Furthermore:

> *Among treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of gender or year level?*
>
> *Within treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of gender or year level?*

First, it was hypothesised that students in the Combined mathematics self-efficacy and theory-of-intelligence interventions group would show greater increases in theory-of-intelligence, mathematics self-efficacy, and achievement, than students in the Mathematics self-efficacy intervention and Control groups, as suggested by Blackwell et al.'s (2007) findings.

Secondly, it was hypothesised that students in the Mathematics self-efficacy intervention group would show greater increases in mathematics self-efficacy and achievement than those in the Control group, consistent with the findings of Siegle and McCoach (2007). These first two hypotheses were also expected to be reflected in between-group differences according to gender and year level.

Thirdly, it was hypothesised that mathematics self-efficacy would be stronger for Year 4 students than Year 5 (Eccles et al., 1993; Frey & Ruble, 1987; Pajares, 1996a), and that boys would report higher levels of self-efficacy than girls, as suggested by previous studies (Eccles et al., 1993; Ewers & Wood, 1993; Lloyd et al., 2005).

Fourthly, Year 4 students were expected to indicate a stronger incremental theory-of-intelligence than Year 5 students (Ablard & Mills, 1996; Dweck & Elliott, 1983; Leonardi & Gialamas, 2002; Kurtz-Costes et al., 2005; Pintrich & Schunk, 1996). As suggested by previous research (Dweck & Leggett, 1988; Räty et al., 2004; Stipek & Gralinski, 1991), it was hypothesised that girls would tend towards an entity belief more than boys.

Finally, the mathematics achievement of Year 5 students was expected to exceed that of Year 4 (Darr et al., 2007), with no significant gender difference in achievement (Young-Loveridge, 2010). Analysis of variance was used to test these hypotheses.

Having considered how the three variables might differ for the three treatment groups, relationships between mathematics self-efficacy, theory-of-intelligence, and achievement within groups were tested using correlation and regression analysis to answer the question:

> *How are students' theory-of-intelligence, mathematics self-efficacy, and mathematics achievement related?*

It was hypothesised that an entity theory-of-intelligence would be associated with low mathematics self-efficacy and achievement, and an incremental belief with high self-efficacy and achievement (Chen & Pajares, 2010; Wood & Bandura, 1989), and that mathematics self-efficacy and achievement would be correlated (Pajares & Miller, 1994; Schunk & Gunn, 1986).

Relationships between the beliefs of teachers and students were also of interest:

> *Is there a correlation between a teacher's theory-of-intelligence and their students' theory-of-intelligence?*
>
> *Is there a correlation between a teacher's self-efficacy for teaching mathematics and their students' mathematics self-efficacy?*

Consistent with previous studies (Anderson et al., 1988; Stipek et al., 2001) that identified associations between teachers' beliefs and those of their students, it was hypothesised that teachers' theory-of-intelligence and self-efficacy would be positively

associated with their students' theory-of-intelligence and self-efficacy (respectively). It was also hypothesised that teachers' beliefs would concomitantly be associated with students' achievement, particularly in the second half of the school year. An examination of correlations was used to examine these hypotheses.

The nature of students' and teachers' beliefs about the malleability of intelligence, which tends to be represented as dichotomous in the research literature (for example, Dweck & Bempechat, 1983; Dweck et al., 1995) was also of interest:

What is the nature of students' and teachers' theory-of-intelligence?

Students' and teachers' theory-of-intelligence beliefs were hypothesised to be non-dichotomous, but whether they might form a continuum or be multi-dimensional was unclear. Findings from both quantitative and qualitative data were combined to answer this question.

Guided by the literature (Ablard & Mills, 1996; Dweck & Elliott, 1983; Leonardi & Gialamas, 2002; Kurtz-Costes et al., 2005; Pintrich & Schunk, 1996), it was expected that younger students would have more strongly incremental beliefs than older students, and that this might be associated with differences in definitions of intelligence, associated with students' age and cognitive development.

Do students' theory-of-intelligence beliefs change as they get older?

It was hypothesised that Control group students' mean score for theory-of-intelligence would decrease over the three time points, as they got older.

A combined analysis of the quantitative and qualitative data sets addressed the following question:

Is there convergence between the quantitative and qualitative findings?

The main purpose for using mixed methods in this sequential explanatory study was to triangulate the data (Webb, Campbell, Schwartz, & Sechrest, 1966) – to check for convergence and contradictions – in order to test the validity of the mathematics self-efficacy and theory-of-intelligence instruments when used with primary students. Furthermore, any inconsistency between the quantitative and qualitative data might suggest some inadequacy in the conceptualisation of the constructs of mathematics self-efficacy or theory-of-intelligence.

CHAPTER 5
Methods

Methodological paradigms and mixed-methods research

A theoretical perspective shapes how a researcher conceptualises their research, the methods they choose to employ, and their interpretation of the outcomes. Rather than opting for a single methodology or theoretical perspective, a pragmatic perspective involves pluralism (Onwuegbuzie & Johnson, 2006), combining the strengths of qualitative and quantitative methodologies, one providing "deep, rich" data and the other producing "hard, generalizable" data (Sieber, 1973, p. 1335). Pragmatists can be thought of as "anti-dualists" (Rorty, 1999, p. ixx), avoiding the traditional dualism between quantitative and qualitative methodologies that have been at the heart of the so-called "paradigm wars" outlined in Sieber's (1973) paper. The many possibilities for mixed-methods research can be thought of as being located along a continuum of quantitative and qualitative methods integration, according to Teddlie and Tashakkori (2009).

The following definition of mixed methods, developed by Johnson, Onwuegbuzie, and Turner (2007) by synthesising definitions provided by leaders in the field of mixed-methods research, was adopted in the present study:

> Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (p. 123)

When quantitative and qualitative data are both used in the same study, decisions must be made regarding the weighting of each, the points at which the two are mixed, and when in the study each method is used (Creswell & Plano Clark, 2007). There is much discussion in the mixed-methods literature about the many ways in which quantitative and qualitative methods can be integrated in research (Bazeley, 2009; Yin, 2006), which range from "simply combining different data collection methods, analysis strategies, or research designs" to "creating a dialogue between different ways of seeing, interpreting, and knowing" (Maxwell, 2010, p. 478).

Mixed methods in the present study

The overall theoretical lens that guided this study was a pragmatic worldview, where the researcher "bases the inquiry on the assumption that collecting diverse types of data best provides an understanding of a research problem" (Creswell, 2009, p. 18). This is consistent with the idea of multiple theories throwing light on the same situation from different angles, resulting in a more complete picture, discussed in Chapter 2. This study aimed to investigate hypotheses about the relationships between three variables that were initially measured for 343 students, necessitating a perspective consistent with methods that supported the objective statistical analysis of data. Quantitative methods are typically associated with a post-positivist worldview, and aim to connect causes with outcomes, and frame questions as sets of testable hypotheses.

In addition, I was interested to learn more about students' and teachers' understanding of mathematics self-efficacy and theory-of-intelligence. Recognising that, often through interactions with others, individuals develop their own perceptions about their abilities and their own subjective meanings of concepts such as intelligence, I sought to reveal this complexity. This was more consistent with a social constructivist worldview, usually associated with qualitative methods. At different times during the course of the present sequential explanatory study, the paradigm shifted (Creswell, 2011; Creswell & Plano Clark, 2007) between these two perspectives, in order to achieve the aims of the study. As such, the paradigms were seen as complementary rather than conflicting.

In an area that has traditionally been dominated by quantitative research, another reason for collecting both quantitative and qualitative data was to check for a convergence of findings from the datasets – the "corroboration" referred to earlier in Johnson et al.'s (2007) definition of mixed-methods research. Such triangulation (Webb et al., 1966) was especially important to check the primary student participants' beliefs and understandings in connection with their questionnaire responses. In particular, it was thought that such young participants might not yet have an understanding of the term *intelligence*, and that this might affect their questionnaire responses.

The mixed-methods design of the present study was determined by the original research questions, as recommended by Tashakkori and Teddlie (2003), and the research questions, in turn, were further refined by the decision to conduct a

mixed-methods study. Quantitative methods were prioritised, and I integrated these with qualitative methods when this helped to address the research questions. For instance, data from the first questionnaires were used to determine which students were to be interviewed, and were also the subject of enquiry during those interviews. Findings from analyses of both the quantitative and qualitative datasets were compared to check for convergence and contradictions.

Blending quantitative and qualitative methods was intended to take advantage of the inherent strengths of both methodologies, and at the same time minimise their weaknesses, thereby contributing to the validity of the findings. While the quantitative data allowed a breadth of coverage, the qualitative data with a small cross-section of students and their teachers provided a rich description of individuals' experiences. Neither quantitative nor qualitative methods alone would have captured the complexity of students' and teachers' beliefs. Complementarity, therefore, was another reason for employing mixed methods, aimed at developing a more complete picture of students' and teachers' beliefs (Hesse-Biber, 2010), thereby strengthening the study's conclusions.

Participants

The focus of the study was the 152 Year 4 and 5 students (aged 7 years and 7 months to 9 years and 6 months) from a total sample of 343 Year 3 to Year 6 students, whose ages ranged from 6 years and 7 months to 10 years and 6 months at the start of the research. Many primary classes include students from two year levels (in this case, Years 3 and 4, and Years 5 and 6), and the initial inclusion of Years 3 and 6 students was for practical reasons. Their 24 teachers, eight of whom were male, also participated in this 14-month study. All participants were from decile 7-10 schools in the Wellington area, avoiding the student transience more prevalent in low decile schools (Gilbert, 2005) that might have compromised this short-term longitudinal study. Further details about the sample are reported in Chapter 6.

Quantitative instruments

Two student measures were used – one comprised selected items from a commercially available series of mathematics assessments, and the other was a questionnaire developed for the present study – to identify students' mathematics self-efficacy and their theory-of-intelligence. A teacher questionnaire measured their theory-of-intelligence and self-efficacy for teaching mathematics (see Appendix A for both questionnaires).

Student mathematics achievement measure

Ten age-appropriate items were selected from the *Progressive Achievement Test: Mathematics* (Darr et al., 2007) for each year group (20 items in total). Each problem was multi-choice in format. Specific item difficulty information included in Darr et al. enabled the selection of items of a range of difficulty levels for each year level. Students referred to the same problems when their mathematics self-efficacy was measured, allowing for well-aligned comparison of self-efficacy and achievement.

Student theory-of-intelligence and mathematics self-efficacy measure

Students' theory-of-intelligence was measured with six items from Dweck (2000) (see Table 3.1). These were a combination of three positively-worded items, such as, "Your intelligence is something about you that you can't change very much", followed by three negatively-worded items, such as, "You can always greatly change how intelligent you are".

Students were asked to judge their mathematics self-efficacy in relation to the 10 *Progressive Achievement Test: Mathematics* problems which they were later asked to solve in the achievement test. For example, Year 5 students were asked how much they agreed or disagreed that they could solve the problems, "What does the 7 stand for in 756?" and, "Ants have 6 legs. How many legs in total would there be on 43 ants?" (A complete list of Year 5 items is shown in Chapter 6, in Table 6.2c.) Problems were presented on large (A3) sheets of paper, and were shown to the students for around 4 seconds. This brief exposure was to allow students sufficient time to make a self-efficacy judgment, but insufficient time to actually solve each problem. They then recorded their level of self-efficacy for solving that particular problem, using a 6-point Likert scale that ranged from *Strongly disagree* [that I could solve the problem] at one end to *Strongly agree* at the other – the same scale

that was used for their theory-of-intelligence responses. The mathematics self-efficacy items for each year level were randomly ordered in terms of difficulty. The student questionnaire is included in Appendix A.

Teacher theory-of-intelligence and self-efficacy for teaching mathematics measure

The teacher questionnaire comprised 21 items – eight measuring theory-of-intelligence (drawn from Dweck, 2000), and 13 measuring their self-efficacy for teaching mathematics (adapted from Gibson & Dembo, 1984, and Woolfolk & Hoy, 1990). Six versions of the questionnaire were developed, each comprising the same items in different random orders. Teachers were asked to circle their response to each statement using the same 6-point Likert scale included in the student questionnaire. The teacher questionnaire is in Appendix A.

Qualitative data gathering instruments

A purposive sample of Year 4 and 5 students (n = 46) was interviewed, as were 15 teachers from the two intervention groups. All interviews were audiotaped, and field notes were made during, and at the conclusion of, each interview.

Student interviews

The quantitative data were used to identify students with extreme total raw scores for self-efficacy and theory-of-intelligence. This was to facilitate the selection of equal groups of students in each of four categories: low mathematics self-efficacy + entity belief; low mathematics self-efficacy + incremental belief; high mathematics self-efficacy + entity belief; and high mathematics self-efficacy + incremental belief.

However, this process proved less than straightforward, as very few students had extremely low scores for mathematics self-efficacy or theory-of-intelligence, and still fewer indicated a combination of both. Instead, the middle one-third of the student data was put aside, and the students chosen for interview were those whose two scores were located in combinations of each of the bottom and top one-third of the two scales. A cluster analysis of the Year 4 and 5 students' Time 1 logit scores (explained shortly) on a two-dimensional plane representing mathematics self-efficacy and theory-of-intelligence identified two clusters of scores; one cluster of 68 students around a point at co-ordinates (1.31, .55) logits for theory-of-intelligence and self-efficacy, respectively, and the remaining 84 students clustering

around (-1.18, -.59) logits. Students who had been selected for interviewing on the basis of their combination of high scores for both self-efficacy and theory-of-intelligence were all included in the former cluster, and those selected because of their low scores for both were in the latter.

Student interviews were conducted in whatever spaces the schools provided. I collected each student from their classroom, and engaged them in conversation on the way to the interview venue. Before the actual interview began, students were also encouraged to answer all the questions, and were thanked for their help. To put the student at ease and to introduce the focus on mathematics, I began by asking them about the things they enjoyed most, and least, about mathematics.

The first interviews, in Term 2 2010, focused on each student's ideas about teacher-student feedback, the student's mathematics self-efficacy, and their theory-of-intelligence. Interview questions included:

- Tell me what you think intelligence is.
- What makes a person intelligent? How do they get to be intelligent?
- In the questionnaire that you did with me last term, it looked as though you (either) thought that you can solve all the maths problems I showed you, (or) thought you could solve most of the maths problems I showed you, (or) thought you couldn't solve most of the maths problems I showed you. Is that right? Tell me why you thought this.

Part-way through the Time 1 interviews, an addition was made to the interview schedule, in response to students' comments about intelligence. The question, "How much can you change your intelligence?" is included in the final schedule in Appendix B.

In the second student interview around 7 months later, some questions were repeated, with additional items included to identify the effects of peer modelling on students. Where students' reported mathematics self-efficacy and/or theory-of-intelligence seemed to have changed from the Time 1 to Time 2 questionnaires, they were asked why this might have happened. Students in the Combined interventions group were also asked specifically about the intervention lessons, and how they thought these had affected their learning. The Time 2 interview schedule is also in Appendix B.

Teacher interviews

Teachers from the Combined mathematics self-efficacy and theory-of-intelligence interventions and Mathematics self-efficacy intervention groups were also interviewed. I had met each teacher prior to their first interview, during the recruitment and consent process. Teachers were released from their classroom to be interviewed on both occasions.

Questions in the first interview focused on their current teacher-student feedback practices, ways in which their beliefs about intelligence might affect their interactions with students, and their ideas about students' mathematics self-efficacy and how they might influence it. Interview items included:

- In your questionnaire responses, you indicated that you believe (either) intelligence can be changed, (or) intelligence cannot be changed much at all. Is that right? Tell me why you think this.
- How do you think this belief might affect your teaching?
- What factors do you think contribute to students' self-beliefs about their ability in mathematics?
- Which of those factors can you influence, and how do you go about this?

The later interview included many of the same items, with additional questions to identify ways in which teachers had changed their practice, specifically to build students' mathematics self-efficacy, and the effects they noticed among their students. An additional set of questions were asked of Combined mathematics self-efficacy and theory-of-intelligence interventions group teachers to identify how long they spent on the intervention lessons, and how they perceived these lessons had affected students. Teachers were also asked how the start of the 2011 school year might be different in their class as a result of their participation in the interventions. The teacher interview schedules for Term 2 and Term 4 are included in Appendix B.

Design overview

The research design used in this study most closely resembled what Creswell and Plano Clark (2007) described as a sequential explanatory mixed-methods design, and included qualitative components within a strongly quantitative, quasi-experimental research methodology, as shown in the overview in Figure 5.1. Morse's (1991) notation system is used, shortening qualitative and quantitative to "qual" and "QUAN", using uppercase to indicate major emphasis.

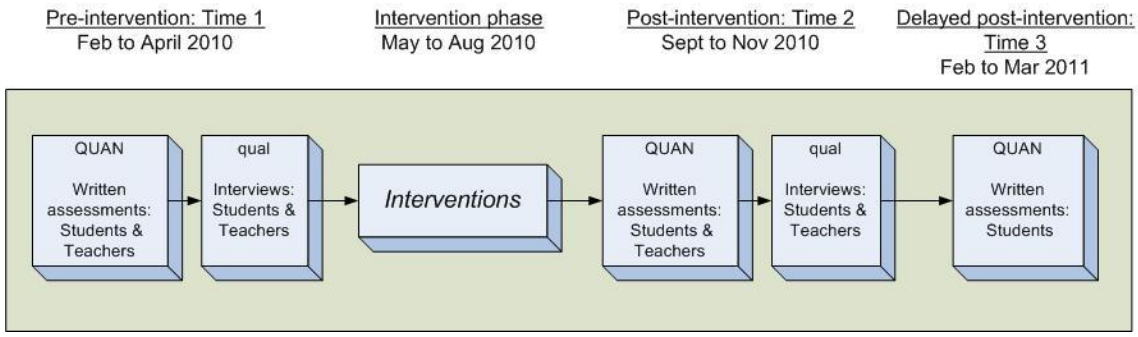


Figure 5.1. Overview of the research design.

The sequential, explanatory, quasi-experimental research design with interventions and three data collection times over a 14-month timeframe

With the aim of allowing for more reliable measures of the effects of two separate interventions, three distinct groups of teachers and students were involved in different treatment conditions:

- The Control group participated in no intervention;
- The Mathematics self-efficacy intervention group participated in the mathematics self-efficacy intervention;
- The Combined mathematics self-efficacy and theory-of-intelligence interventions group participated in the mathematics self-efficacy intervention, followed by the theory-of-intelligence intervention.

In order to identify any intervention effects (both immediately post-intervention, and around 7 months after that), and therefore to answer the research questions, three waves of data were collected over a 14-month period.

Allocation of participants to treatment groups

When all consent forms had been completed and returned, schools were organised into three approximately matched groups, shown in Table 5.1. Each group had an approximately similar number of students, number of teachers, and spread of year levels of students. Students who had completed the *Progressive Achievement Test: Mathematics* before they completed the student questionnaire were allocated to separate groups to manage the bias this might cause.

The groups were then randomly allocated to treatment groups as follows:

- Group 1: Combined mathematics self-efficacy and theory-of-intelligence interventions group;
- Group 2: Control group;
- Group 3: Mathematics self-efficacy intervention group.

Table 5.1: The three treatment groups

The three groups of schools, with the number of teachers and consenting Year 4 and 5 students (n = 152) at each school who provided data at each of Times 1, 2 and 3.

	Number of teachers	PAT: Mathematics completed before questionnaire	Total number of Year 4 and 5 students who provided data at Times 1, 2, and 3	Number of students in each Group
Group 1 (8 teachers)	3	-	17	61
	4	4 classes	37	
	1	-	7	
Group 2 (7 teachers)	4	-	31	50
	3	-	19	
Group 3 (9 teachers)	3	3 classes	14	41
	6	-	27	

Procedure

Before the study got underway, a pilot of the questionnaires was conducted.

Pilot

Student questionnaire procedures

A total of 193 Year 3 to 6 students completed questionnaires during September and October of 2009. I administered the questionnaire class by class. To be sure that all students understood how to use the Likert scale, a modified version of Bandura and Schunk's (1981) introduction was used. First, the six labels for the Likert scale were presented to the class on large cards which were then displayed in a horizontal line (in the same order as they appeared on the questionnaire) on a whiteboard, to provide a visual reference point. Next, the teacher nominated a student to take the role of peer model. This student stood at the front of the class, while the other students were asked to consider how much they agreed or disagreed that the student could jump to a given marker. This was repeated several times with the marker at different distances from the student, with some discussion of students' judgments at each point. The focus here was to check that students were able to

use the “agree”/“disagree” language in the labels that they would be asked to use in the questionnaire. The accuracy of their judgments was not of interest, so students were told that not until after they had completed the questionnaire could the student actually attempt the jumps.

More time was spent introducing the scale to Year 3-4 students than those in Year 5-6 classes. As a final check that students understood the questionnaire task, a practice example was included at the start of the questionnaire. Students used the Likert scale to indicate how much they agreed or disagreed with the statement, “Chocolate is good for you.” The brief discussion of their responses aimed to highlight that a variety of responses were equally valid, and that it was important for students to respond honestly. I checked that students had recorded a response for this example before starting the actual questionnaire items, and emphasised during the introduction that there were no wrong answers for the questionnaire items.

In one of the first Year 3-4 classes to complete the questionnaire, a Year 3 student asked, “What’s intelligence?” I invited other students to describe intelligence, and they responded with statements such as, “It’s how clever you are”. The purpose of the questionnaire was not to test students’ understanding of “intelligence”, so in subsequent classes I asked students to share their definitions of “intelligence” before beginning the questionnaire. The 12 theory-of-intelligence items included in the original student questionnaire were drawn from Dweck (2000) and Dweck and Molden (2005).

For the mathematics self-efficacy items, students were shown an enlarged (A3) copy of each mathematics problem for approximately four seconds, while the problem was read aloud to them to control for any reading difficulties. The same problems were shown to all students during the pilot, regardless of year group. Although students were specifically instructed not to actually calculate the solution, but to consider whether they believed that they could, some might have done so, especially if they were mathematically able. One Year 4 student attempted to record solutions to the mathematics problems on his questionnaire, despite being instructed to the contrary on three occasions. Otherwise, all students appeared to follow the technical aspect of responding to each item, circling one point on the Likert scale.

Analysis

To analyse the data, numeric values of 1 (strongly disagree) to 6 (strongly agree) were assigned to Likert scale points. Data for negatively-worded items were reverse coded. The ordinal data were plotted on histograms, which showed no clumping of responses; a range of responses was evident for all items.

An initial principal components analysis with varimax rotation of Year 3 to 6 students' responses extracted six factors with eigenvalues greater than one, with a lot of cross-loading of items. Because this was not readily interpretable in relation to theoretical considerations, the analysis was repeated using only the target Year 4 and 5 (n = 123) students' data. Factor 1 explained 24% of the variance, Factor 2: 10%, Factor 3: 9%, and the remaining three factors each explained a combined 17%. The scree plot confirmed three main factors, with a leveling off at the fourth factor. Loadings on the first three factors are shown in Table C.1 (see Appendix C). Mathematics self-efficacy items (items 13-22) loaded on Factor 1, items indicating an entity theory-of-intelligence (items 1, 2, and 3) on Factor 2, and those indicating an incremental theory-of-intelligence (4, 5, and 6) on Factor 3. Weak factor loadings were evident for responses to items 7 to 12 inclusive, so these items were dropped from the final questionnaire. This left six items related to theory-of-intelligence, and ten items focusing on mathematics self-efficacy.

The item-totals were all strongly correlated; correlations for the six items relating to students' theory-of-intelligence were all above 0.85, and correlations for the ten items relating to their mathematics self-efficacy were above 0.95. Internal reliability was checked using Cronbach's alpha, with values for the final item sets of α = .87 for mathematics self-efficacy, α = .65 for entity theory-of-intelligence, and α = .69 for incremental theory-of-intelligence. Although the theory-of-intelligence alpha values were slightly lower than the commonly used benchmark of .70 (Schmitt, 1996), this was probably related to the likely imprecision of data collected from young participants.

Teacher questionnaire procedures

The trial teacher questionnaire comprised 24 items (included in Table C.2 in Appendix C). Eight of these came from Dweck (2000) and were intended to assess teachers' theory-of-intelligence, with six of the same items included in the student questionnaire. An additional 16 items, aimed at assessing teachers' self-efficacy

for teaching mathematics, were from Woolfolk and Hoy (1990) and Hoy and Woolfolk (1993), who in turn had included eight items from Gibson and Dembo's (1984) earlier study. They had also used two items from the Rand study (Armor et al., 1976), included in other teacher self-efficacy studies (Midgley et al., 1989; Woolfolk & Hoy, 1990).

The original items were modified for the present study to relate them specifically to teaching mathematics. The words that were added to the original Rand items are shown here in brackets, and are typical of the modifications made:

- When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance [in mathematics] depends on his or her home environment.
- If I really try hard in my [mathematics] teaching, I can get through to even the most difficult or unmotivated students.

Beneath each item in the questionnaire, a line was provided for teachers to write a short comment about the item, should they wish to.

Colleagues in the Australasian mathematics education community administered the trial teacher questionnaire to groups of teachers, with teachers from Wellington schools that were to be invited to participate in the study excluded. Seventy-four completed teacher questionnaires were received by the end of November 2009. Teacher data were coded the same way as the student data. However, 13 teacher respondents drew one circle around two points on the scale, for example, encompassing both *disagree* and *mostly disagree*, or marked a line halfway between two points on the Likert scale; all 32 of these types of responses (one respondent was responsible for 12) were coded by systematically alternating between coding the lower and the higher of the two, rather than treating them as missing data.

In the space provided for teachers to describe which aspect of an item may have been unclear, four respondents recorded a comment about items related to teachers' self-efficacy for teaching mathematics. These were as follows:

- Item 9. When a student does better than usual in maths, many times it is because I exert a little extra effort. Comment: "Teachers always exert effort!"
- Item 10. The amount a student can learn in maths is primarily related to family background. Comment: "Much of what a student can learn depends on teaching";
- Item 20. Even a teacher with good maths teaching abilities may not reach many students. Comment: "Don't know";

- Item 24. Some students need to be placed in slower maths groups so they are not subjected to unrealistic expectations. Comment: “By slower do you mean lower?”

One respondent wrote an overall comment at the end of their questionnaire: “This is a confusing questionnaire – most questions are loaded and will attract a wide variety of outcomes.”

Analysis

Histograms of the teachers’ data showed a range of responses for all items. A principal components analysis extracted three main factors that explained a total of 49% of the variance, with an additional four factors with eigenvalues greater than one together explaining a further 22% of the variance. Factor 1 was interpreted as an incremental theory-of-intelligence, Factor 2 as a belief that teachers influence students’ learning, and Factor 3 as a belief that influences other than teachers are associated with students’ learning. The loadings for these factors are shown in Table C.2 in Appendix C.

Three items (9, 21, and 25) had cross-loadings on two of the three main factors of less than 0.4, and were omitted from the final questionnaire. Correlations between items relating to theory-of-intelligence all greater than 0.69, and those relating to self-efficacy for teaching mathematics consistently above 0.95. Cronbach’s alpha reliability coefficients for the final item sets were: α = .87 for incremental theory-of-intelligence items; and α = .90 for the self-efficacy items.

The questionnaire instructions were modified to clearly state, “Please circle one response only.” The final version of the 21-item teacher questionnaire is included in Appendix A.

Pre-intervention: Time 1

Time 1 data gathering began as soon as the student consent process was completed for each class in Term 1 of 2010. I spent between 30 and 40 minutes administering the student questionnaire with each class, reading the items aloud to students. Before they began the questionnaire, students’ ideas were used to establish a shared definition of intelligence as how smart a person is, or how clever they are.

The student questionnaire was administered around a fortnight prior to most students completing the mathematics achievement measure. Principals provided

me with access to their students' online *Progressive Achievement Test: Mathematics* data for tests that were administered at three points during the 14-month study.

Most teachers completed their questionnaire while the students did theirs. Where a teacher was absent, they completed the questionnaire later and posted it to me. Teachers also provided class lists that were divided into year levels and gender, providing demographic information for students.

Interviews with students and intervention teachers were held at the beginning of Term 2. Student interviews were generally shorter than 10 minutes, and were transcribed in full. Teacher interviews lasted up to 45 minutes and were audio-taped, and field notes were made. I listened to the interviews later, and on the field notes highlighted excerpts to be transcribed. Excerpts were selected on the basis of relevance to the research questions, or to additional themes emerging from the data. As themes seemed to emerge from the teacher interviews, field notes and audiotapes were checked for further evidence, in an iterative process.

The interventions

Teachers in the two treatment groups met with me on three occasions over a 21 to 24-week period. Initial meetings were held in the later part of Term 2, followed by a second round of meetings in the first half of Term 3, and final meetings early in Term 4. Meetings for teachers in the two intervention groups were held separately to avoid teachers in the Combined interventions group sharing information about theory-of-intelligence with teachers in the Mathematics self-efficacy intervention group. The duration of workshops varied from 1 to 2 hours, depending partly on how much discussion there was and also on the size of the group (the smallest group had three teachers and the largest was a whole staff of around 12 at one school). For the Combined mathematics self-efficacy and theory-of-intelligence interventions group, Workshop 2 was longer to accommodate the additional content associated with the theory-of-intelligence intervention.

Intervention 1: Students' mathematics self-efficacy

The mathematics self-efficacy intervention focussed on the role the teacher plays in developing students' mathematics self-efficacy, and involved teachers in both intervention groups. An overview of the foci for each workshop is shown in Table 5.2.

The following instructional strategies, drawn from recommendations made by Hattie and Timperley (2007), Siegle and McCoach (2007), Nicol and Macfarlane-Dick (2006), and Schunk and Pajares (2002), were included in this intervention. Each of these strategies relates to informing students about their progress in learning:

- Making explicit the learning intentions and their supporting success criteria – goals should be specific and proximal. Ideally the success criteria will be negotiated with the students, and should clarify what good performance will be;
- Giving students feedback that encourages them to identify progress in their learning with specific reference to the learning intentions and success criteria, and indicates the next steps they need to take;
- Having students record each day/week one thing that they learnt or excelled at in mathematics, to facilitate the development of self-assessment and reflection.

Table 5.2: An overview of the mathematics self-efficacy intervention workshops

Workshop	Foci
Workshop 1 (June, 2010)	• What is maths self-efficacy? What are its effects on students and teachers? • Strategies that can help develop a student's maths self-efficacy. • Teachers setting goals for including strategies in their teaching practice.
Workshop 2 (July/August, 2010)	• Review progress and effects of mathematics self-efficacy strategies; • Teacher-student feedback, including Tunstall and Gipps' (1996a) typology.
Workshop 3 (November, 2010)	• Evaluate progress and effects of mathematics self-efficacy strategies; • Discuss strategy grouping for mathematics and students' maths self-efficacy; • Discuss articles related to feedback in numeracy; • Summarise what has been learnt, to build on in 2011.

In addition to these strategies, teachers were encouraged to use similar student peers as models, rather than using teacher modelling. Also discussed at the first workshop was ways teachers could help children to develop ways of coping when they found learning difficult. Drawing on Schunk et al. (1987), strategies that were recommended included: teachers using "think-alouds" to model their own responses to difficult learning experiences; using student models to share their

thought processes when they have dealt constructively with working through difficulties; and emphasising the value of effort and perseverance.

Teachers reflected on their feedback practices using Tunstall and Gipps' (1996a) typology (see Figure 4.1), which was discussed in detail with teachers at Workshop 2. Several key readings (Pajares, 2005; Siegle & McCoach, 2007; Tunstall & Gipps, 1996a) were presented and discussed at the mathematics self-efficacy meetings.

Intervention 2: Students' theory-of-intelligence

This intervention involved only the Combined mathematics self-efficacy and theory-of-intelligence interventions group teachers who met in two groups of four. The main focus was to support teachers to explicitly teach students about their capacity to develop their intelligence. In addition to the workshops outlined in Table 5.2, Workshop 2 was extended by around 45 minutes.

Themes included in this intervention were the brain's structure and function, and how the brain behaves like a muscle, in that it can be developed with exercise. Teachers were taken through two clearly-defined lessons (see Appendix D) which they then took back to their classrooms to teach to their students. I suggested to teachers that each lesson needed around 45 minutes. Copies of lesson plans and posters about the brain were given to each teacher, along with a collection of library books. A plastic, pull-apart model of a brain was shared among teachers at the three schools in this group, to support the lessons.

To help maintain consistency with Dweck's work in the present study, her (2010) article, *Mind-sets and equitable education*, was presented and discussed. Additionally, the main ideas for the intervention were modelled on Blackwell et al.'s (2007) intervention, that were reported to boost the mathematics achievement of students in seventh grade. As already explained, Dweck's items were used to measure theory-of-intelligence.

Post-intervention: Time 2

At the end of Term 3, students and teachers completed the same measures. Early in Term 4, interviews were held with the same students. The interview schedule comprised some of the same questions asked in the first interview, and additional items aimed at identifying students' perceptions of effects of the interventions for those in the affected group. Second interviews with teachers in the intervention

groups included similar modifications. Both Time 2 interview schedules are included in Appendix B.

Delayed post-intervention: Time 3

The student questionnaire and achievement measure were the only data collected at Time 3. Each school administered the *Progressive Achievement Test: Mathematics* during the first term of 2011, after students had completed the questionnaire for a third time. Because the *Progressive Achievement Test: Mathematics* is an age-appropriate assessment, in 2010 Year 4 and 5 students completed tests 1 and 2, and in 2011 they completed tests 2 and 3, respectively. Self-efficacy judgments were made with reference to items from these tests.

Analysis of quantitative data

Decisions about which data to include in the final analysis were made on the basis of principal components analysis and correlations between item-totals for different year levels' data. Students with missing data were also removed.

A Rasch (1980) measurement model was applied to the remaining student data, taking individual *Progressive Achievement Test: Mathematics* items' calibrations for difficulty into account both for *Progressive Achievement Test: Mathematics* data and mathematics self-efficacy data, which were judgments made with reference to the same mathematics problems. Both estimates of students' self-efficacy, and of their mathematics achievement, were derived using the difficulty parameters of the specific *Progressive Achievement Test: Mathematics* items, allowing for meaningful comparison between Rasch data for mathematics self-efficacy and achievement.

Rasch measurement was also applied to students' theory-of-intelligence data, with difficulty estimates for each item calculated using a maximum log likelihood procedure. The theory-of-intelligence scale was not connected to the self-efficacy and achievement scales in the same way, so a comparison could not be drawn, for instance, between a student's ratings on the mathematics self-efficacy scale and the theory-of-intelligence scale.

Applying Rasch measurement enabled students' logit scores for mathematics self-efficacy, achievement of the *Progressive Achievement Test: Mathematics*, and theory-of-intelligence to be treated as continuous data and analysed accordingly. Students who gained maximum raw scores for self-efficacy, achievement, or theory-of-intelligence would theoretically have infinite ability estimates in a Rasch

model. Rather than omitting their data from the following analyses, maximum raw scores were given the logit score assigned to the maximum score-but-one for their year level; for instance, if a Year 5 student correctly answered all 10 maths problems, their achievement logit score was equivalent to that of a Year 5 student who had a raw score of 9. Likewise, minimum raw scores were assigned the minimum score-but-one for their year level. The data represented here, therefore, slightly underestimate all three measures.

A Levene's test of homogeneity of error variance was used to check the assumption of equal variances before the three groups' data were analysed, and because variances were unequal, students' scores were standardised. A series of repeated-measures analyses of variance, and correlational analyses were used to address the research questions.

Analysis of qualitative data

Transcripts of student interviews were imported into NVivo (version 9) for analysis. Each student's data were treated as an individual case, which was ascribed attributes indicating the student's treatment group, year level, and gender. Also included as attributes were low/medium/high indications of their Time 1 mathematics self-efficacy and theory-of-intelligence, on which basis students were selected for interviewing. Finally, attributes that indicated their mathematics achievement at Time 1 and Time 3 were included, again using low/medium/high values. This was intended to support the identification of links between the qualitative and quantitative findings.

Thematic analysis was used to analyse the qualitative data. Overall categories were set up for data relating to students' mathematics self-efficacy and theory-of-intelligence. Within these broad categories, codes were then developed from the data. All tentative codes were re-applied to the qualitative data to confirm and refine them in an iterative process. When these initial codes had been decided on, their relationships with the quantitative results and therefore the research questions were considered, and an approximate alignment between many of the codes and the research questions was identified, with further minor adjustments made. Codes that did not contribute to answering research questions were retained for their potential to identify divergences between the qualitative and quantitative data. In order to build a picture of the quantity of responses, as well as a qualitative one, some of the themes were transformed to numerical data (Onwuegbuzie & Teddlie,

2003) by counting the number of responses related to a particular theme. Quantitising of the qualitative data was restricted to frequency counts in order to emphasise the students' and teachers' voices.

Ethical considerations

The original research proposal was assessed and approved by the Victoria University Faculty of Education Ethics Committee. Informed consent was sought from the participating schools' principals (as the Boards of Trustees' representatives), teachers, students' parents/guardians, and students. Copies of all information sheets, consent forms, and confidentiality agreements are included in Appendix E.

The identities of the schools, teachers and students were kept confidential to my supervisors and me. In all writing about this research, pseudonyms have been used and any identifying characteristics excluded. Because access to each school's online *Progressive Achievement Test: Mathematics* data was needed, I signed a letter of confidentiality for each school, undertaking to keep access details confidential, not to alter any data, and to use only data related to consenting students. A colleague who helped with transcribing interviews signed a confidentiality agreement.

To preserve the integrity of the interventions, teachers were not given the results of students' questionnaires; giving teachers this information would have been likely to influence their interactions with students and therefore their implementation of the interventions. For the same reason, I provided teachers in the two intervention groups with no information about the other intervention group.

The findings are to be shared with stakeholders in several ways. To ensure that teachers in each of the three groups have access to any benefits from this study, they will all be invited to an after-school meeting at which I will present a summary of the findings, which will be discussed with participants. Following this meeting, principals of all participating schools will be provided with an electronic version of the summary to include in a newsletter to parents, informing them of the findings. The summary of findings will also be sent to parents who requested this when they signed consent forms at the outset of the study. Finally, the full thesis will be made available to parents, teachers and principals, on request.

Student consent process

I visited each consenting teacher's class to talk to their students about what the research would involve for them, if they chose to participate. This gave students an opportunity to ask me questions, and they were also encouraged to contact me if they had further questions after talking with their parents about their involvement. Two information sheets and consent forms were then sent home with every student: one for the student and one for their parents or guardians. Only one email from a parent was received, forwarded by their child's teacher, explaining that her son was reluctant to participate because he found writing difficult. A response was sent, asking the parent to reassure her son that answers would simply be circled on a Likert-type scale. In some cases, only one of the two consent forms sent home was returned to school completed. If a parent had given consent, but their child had not completed a consent form – something they were unlikely to be familiar with doing – then if students were agreeable to participating on the day, this was taken to be in the spirit of gaining students' consent. Those students who had not returned a parental consent form were given another to take home for signing.

Issues and challenges

Recruitment and the consent process proved to be the two main challenges for this study. During the recruitment phase, several principals declined to participate in the study due to a perceived increase in teachers' workload because of the introduction during 2010 of National Standards; some also said they were concerned about the demands on teachers of implementing the revised curriculum. Recruitment of schools was made more challenging by not being able to tell principals from the outset, in which treatment group their teachers would participate. This meant that principals and teachers were being asked to make a commitment without knowing exactly what they were committing themselves to do. There was also a potential risk that teachers might sign consent forms, hoping to be included in the control group with a minimum of involvement, and then be allocated to one of the intervention groups and withdraw because they were not willing to take on the expected responsibilities.

In one school, a single teacher was eager to participate in the study. The original intention was for groups of at least three teachers in a school to be involved, allowing more opportunities for collaboration and support during the interventions. However, because it had proved difficult to recruit sufficient teachers, and because

this teacher was very supportive of research, she was included. I was mindful of including her during the intervention meetings of which she was a part, along with a group of teachers from one other school.

The consent process for students took considerably longer than was anticipated. In several classes I provided a second set of information sheets and consent forms for students to take home, complete, and return to their teacher. The amount of information for parents to read may have been off-putting for those with limited time or for whom English was an additional language. One school seemed to have particular difficulty gaining parents' consent, and the principal intervened to reassure parents of the value of their support for their children's involvement.

The reality of undertaking research with teachers and students in school settings is complex and messy, and the effects of this are multiplied when a study covers an extended time-frame. Between the first and second waves of data gathering, one teacher from each group left, and a number of students also left schools. Most teacher absences were accommodated (intervention meetings were re-scheduled), but if students were absent on the day questionnaires, mathematics achievement measures, or student interviews were undertaken, this resulted in missing data.

CHAPTER 6
Findings from the Quantitative Data

The student data

Three waves of quantitative data were collected from students in each of the three treatment groups: the Control group, Mathematics self-efficacy intervention group, and Combined mathematics self-efficacy and theory-of-intelligence interventions group. The first wave was collected in Term 1, 2010 prior to the interventions, and the second wave in Term 3 of the same year, post-intervention. The third and final wave of data was gathered during Term 1 of the 2011 school year, to identify any delayed effects of the interventions.

Of 600 Year 3 to 6 students who were invited to participate, 370 consented (approximately 62%), comprising 215 girls and 155 boys. The consent rate ranged from 43% of students at one school, to 84% at another. Of these 370 students, the 216 Year 4 and 5 students were the target group for this analysis. Furthermore, only data for students who had completed the questionnaire and achievement measure at each of the three data-collection points were included, because the analysis focussed on changes over time in individual students' trajectories, as well as the differences between these. (Details of missing data are included in Appendix F.) The final dataset comprised 152 Year 4 and 5 students: 50 from the Control group, 41 from the Mathematics self-efficacy intervention group, and 61 from the Combined mathematics self-efficacy and theory-of-intelligence interventions group. A break-down of the final sample is provided in Table 6.1.

Eighty-eight (58%) of the final sample were girls. This is not reflective of a bias in the schools' populations, and 302 girls and 298 boys were invited to participate. Although a slightly greater number of boys than girls opted not to participate (69 and 57, respectively), the number of boys who did not return consent forms was double that of girls (78 and 37, respectively). When the first data were collected, 16 consenting boys – but no girls – happened to be absent.

Table 6.1: Student participants

Description of the student participants by treatment group, year level, and gender (girl/boy). Treatment groups are Control group (Control), Mathematics self-efficacy intervention group (Self-efficacy), and Combined mathematics self-efficacy and theory-of-intelligence interventions group (Combined)

Treatment group	Year 4		Year 5		Totals		Totals
	G	B	G	B	G	B	
Control	9	9	23	9	32	18	50
Self-efficacy	5	7	16	13	21	20	41
Combined	15	13	20	13	35	26	61
Totals	29	29	59	35	88	64	152

At each of the three data-collection points, Year 4 and 5 students completed written assessments of their mathematics self-efficacy and theory-of-intelligence, and mathematics achievement. A principal components analysis with varimax rotation was used to investigate the dimensionality of Time 1 mathematics self-efficacy and theory-of-intelligence data. Because the mathematics self-efficacy items were different for each year level, analyses were conducted separately with the data for Year 4 (n = 91) and Year 5 (n = 125). The results of these analyses, presented in Tables 6.2a and 6.2b, show that the factor structures for the Time 1 data varied by year level. The mathematics achievement items were not analysed in this way because they have already been extensively tested with a national reference sample of around 1500 students at each of Year 4 and 5 levels, and items have been selected to ensure that the instrument is uni-dimensional. Further details are available in Darr et al. (2007).

For Year 4, Factor 1 accounted for 30% of the variance, with an additional 15% explained by Factor 2, and the scree plot indicating two other eigenvalues slightly greater than one, before a levelling-off effect. Factor 1 was largely indicative of a uni-dimensional mathematics self-efficacy measure, with loadings of .54 to .83 (see Table 6.2a). Interpretation of the three remaining factors was substantively linked to theory-of-intelligence. All theory-of-intelligence items loaded on Factor 2, which seemed to be representative of an incremental belief. Theory-of-intelligence items seemed to be further differentiated by Factors 3 and Factor 4, with the strongly-incremental items loading on the former, and the strongly-entity items loading on

the latter. The first theory-of-intelligence item loaded moderately on all four factors factor. Cronbach's alpha values were $\alpha = .72$ for theory-of-intelligence items and $\alpha = .86$ for mathematics self-efficacy items.

Table 6.2a: Factor loadings on student questionnaire items for Year 4

Factor loadings based on a principal components analysis with varimax rotation for mathematics self-efficacy and theory-of-intelligence items for Year 4 students ($n = 91$) at Time 1. Mathematics self-efficacy items were presented to students in a visual format, often with pictures to support the questions included here. Students were asked to respond by indicating how much they agreed or disagreed that they could solve the mathematics problems, and how much they agreed/disagreed with the statements about intelligence. Items are ordered by weighting on Factor 1. Note: Factor loadings < .3 are not shown.

	Factor 1	Factor 2	Factor 3	Factor 4
Variance	30%	15%	9%	7%
Mathematics self-efficacy items				
Which set of coins is **exactly** the right amount to buy this ice block?	.83			
How many $10 notes will it take to buy this doll?	.78			
Riki won 12 marbles before school, 5 marbles at lunchtime, and 11 marbles after school. How many did he win altogether?	.74			
How many pencils must Kath give to Kyle so they both have the **same number of pencils?**	.66			
Which of these has the numbers ordered from **smallest** to **largest**?	.64			
June is making a string of beads. She is using a repeating pattern. Here is the start of her string of beads. What will the 24^{th} bead she uses look like?	.62			
A sheet of 35 stickers was shared evenly by 7 girls. How many stickers did each girl get?	.60			
Which picture is $^1/_3$ shaded?	.60			
Paul has put some ice block sticks into groups of ten. He has four groups of ten, and five left over. How many ice block sticks does he have altogether?	.59			
Some friends were given 95 chocolates. They ate 72. How many did they have left?	.54			
Theory-of-intelligence items				
You can learn new things, but you can't really change your basic intelligence.	.48	.59	.31	.67
Your intelligence is something about you that you can't change very much.		.60		.86
No matter who you are, you can change your intelligence a lot.		.65	.79	
No matter how much intelligence you have, you can always change it quite a bit.		.59	.72	
You have a certain amount of intelligence, and you really can't do much to change it.		.59		.81
You can always greatly change how intelligent you are.		.63	.77	

Table 6.2b: Factor loadings on student questionnaire items for Year 5

Factor loadings based on a principal components analysis with varimax rotation for mathematics self-efficacy and theory-of-intelligence items for Year 5 students (*n* = 125) at Time 1. Mathematics self-efficacy items were presented to students in a visual format, often with pictures to support the questions included here. Students were asked to respond by indicating how much they agreed or disagreed that they could solve the mathematics problems, and how much they agreed/disagreed with the statements about intelligence. Items are ordered by weighting on Factor 1. Note: Factor loadings < .3 are not shown.

	Factor 1	Factor 2	Factor 3
Variance	31%	18%	8%
Mathematics self-efficacy items			
In a game these counters are used for money. How much would this group of counters be worth altogether?	.70		
How many $10 notes will it take to buy this bike?	.81		
Ants have 6 legs. How many legs in total would there be on 43 ants?	.77		
At the pet show there were 38 dogs, 46 cats, and 29 rabbits. How many animals were there altogether?	.76		
25 + □ = 55 What number should go in the □ to make the sentence true?	.72		
Ligi has drawn arrows on the number line to help solve 121 - □ = 57. What number should go in the □ to make the sentence true?	.71		
If 3 x 12 = 36, then 6 x 12 will equal: A. 2 x 36; B. 3 x 36; C. 6 + 36; D. 12 + 36	.70		
What fraction of this group of circles is shaded?	.66		
What does the 7 stand for in 756?	.59		
This tree has 8 apples on it. If the wind blows ¼ of them onto the ground, how many apples are left on the tree?	.56		
Theory-of-intelligence items			
You have a certain amount of intelligence, and you really can't do much to change it.		.83	
Your intelligence is something about you that you can't change very much.		.73	.35
You can always greatly change how intelligent you are.			.77
No matter how much intelligence you have, you can always change it quite a bit.			.78
You can learn new things, but you can't really change your basic intelligence.		.66	.33
No matter who you are, you can change your intelligence a lot.		.40	.67

Table 6.2b shows the three factors extracted from the Year 5 data. This was the year level for which students' responses gave the most unambiguous factors, with each mathematics self-efficacy item having a primary loading on Factor 1 of .56 or greater, and no cross-loading above .30. Factor loadings for theory-of-intelligence items suggested Factor 2 represented an entity theory-of-intelligence, and Factor 3 was consistent with an incremental theory-of-intelligence, with some cross-loading

between these two factors indicating that they may be part of the same construct, rather than being distinct from one another. Thirty-one per cent of the variance was explained by Factor 1, 18% by Factor 2, and a further 8% by Factor 3. Taking this information into consideration, Cronbach's alpha levels were acceptable for the items measuring mathematics self-efficacy; α =.90, and theory-of-intelligence; α = .79.

The principal components analysis confirmed that, by and large, the mathematics self-efficacy items with which students at both year levels were presented provided a reasonable estimate of their self-efficacy beliefs. The theory-of-intelligence items, however, loaded on at least two factors at each year level, suggesting a less well-defined measure despite the small number of items, and their apparent near identity.

Analysis of variance

A series of analyses of variance was undertaken to identify whether or not mean scores varied significantly for the treatment groups, for girls and boys, and for Year 4 and 5 students. Prior to conducting any analysis of variance, Levene's test of homogeneity of error variance was used to check the assumption of equal variances in each of the three groups. This assumption was not supported for mathematics self-efficacy at Times 1 and 2; F (2, 149) = 2.69, p = .07 and F (2, 149) = 2.60, p = .08, or for theory-of-intelligence at Time 3; F (2, 149) = 2.88, p = .06. For this reason, all logit scores were transformed to standardised z-scores prior to further analysis, by dividing them by their respective standard deviations.

Differences between treatment groups

> *Over the three data collection points, do individual student differences in mathematics self-efficacy, achievement, and theory-of-intelligence vary as a function of treatment group?*

A series of repeated-measures analyses of variance was undertaken to identify changes associated with treatment group, in each of the three dependent variables: students' mathematics self-efficacy, theory-of-intelligence, and mathematics achievement. Each analysis of variance had time (three levels) as the within-subjects factor, and treatment group (three levels: Control group; Mathematics self-

efficacy intervention group; Combined mathematics self-efficacy and theory-of-intelligence interventions group) as the between-subjects factor.

Figure 6.1 shows the mean standardised scores for mathematics self-efficacy, theory-of-intelligence, and mathematics achievement for each treatment group at each of the three data collection points. The first graph in Figure 6.1 shows students' mathematics self-efficacy. Group means varied significantly as a main effect of time; $F(2, 298) = 44.67$, $p < .001$, and treatment group; $F(2, 298) = 3.36$, $p = .04$. There was a significant interaction between time and treatment group affecting mathematics self-efficacy; $F(4, 298) = 3.35$, $p = .01$. The mean score for the Mathematics self-efficacy intervention group increased noticeably from Time 2 to Time 3, with a moderate effect size for this group compared to the Control group; Cohen's $d = .43$. Mean scores for the Control and Combined mathematics self-efficacy and theory-of-intelligence interventions groups were very similar on all three occasions, and at Time 3, all three groups had very similar mean scores.

The interaction effect supported the hypothesis that the mean mathematics self-efficacy of students in the Mathematics self-efficacy intervention group would increase at a greater rate than that of the Control group, although it is interesting that this occurred between the post-intervention and delayed post-intervention time points. On the other hand, the hypothesis that the mean mathematics self-efficacy of the Combined interventions group would increase at a greater rate than that of the two other groups was not supported by the data.

Theory-of-intelligence scores for each treatment group are shown in the top right graph in Figure 6.1. A main effect of time on group theory-of-intelligence means was evident; $F(2, 298) = 18.65$, $p < .001$, but there was no main effect of treatment group; $F < 1$. There was no significant interaction effect of time and treatment on students' theory-of-intelligence; $F(4, 298) = 1.59$, $p = .18$. the second graph in Figure 6.1 shows the mean standardised scores for students' theory-of-intelligence for each treatment group at each of the three data collection points. The hypothesised decrease in the Control group's theory-of-intelligence was not therefore supported by the data.

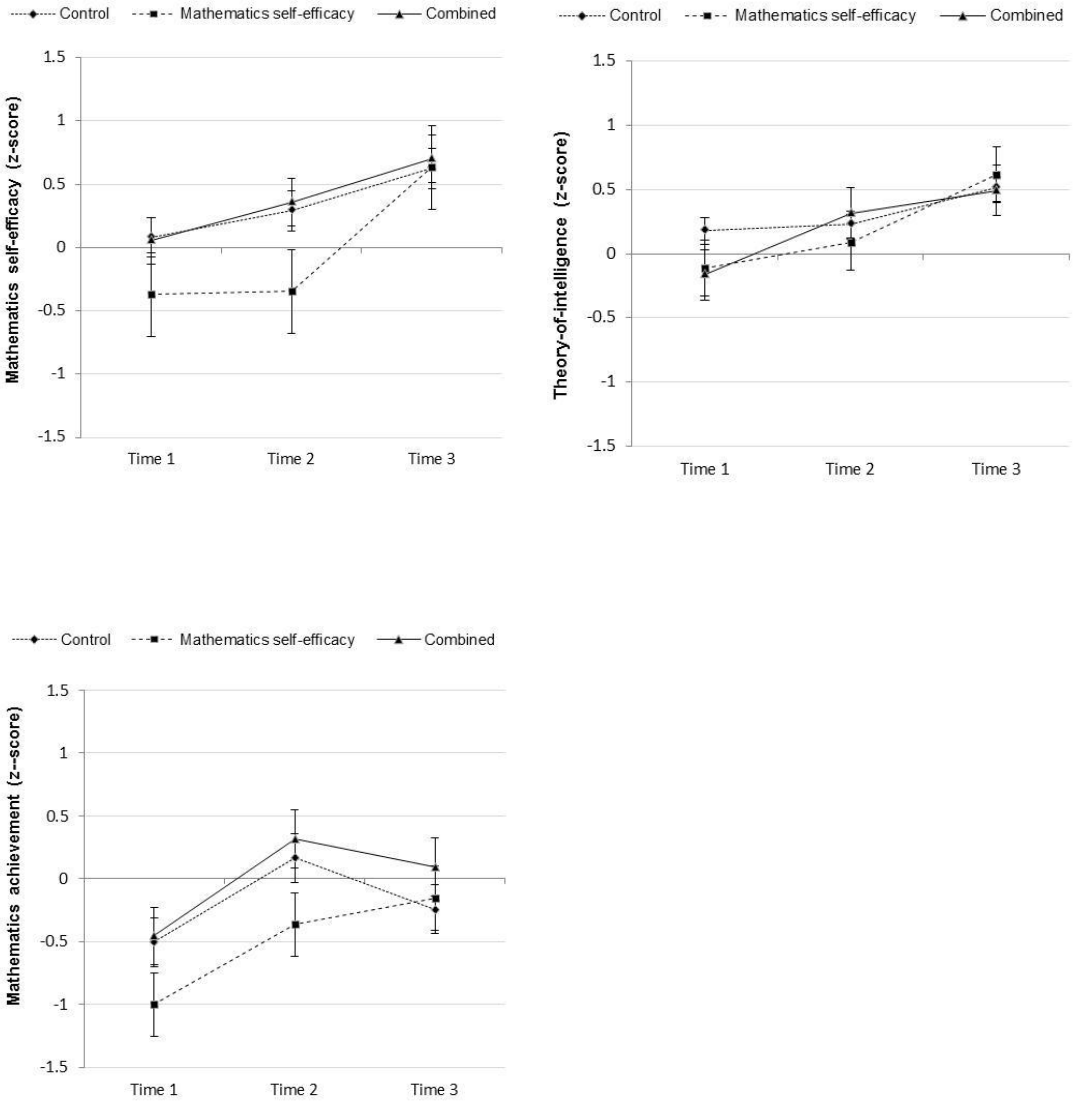


Figure 6.1. Students' mean mathematics self-efficacy (top left), theory-of-intelligence (top right), and mathematics achievement (bottom), by time (three levels) and treatment group (three levels). Treatment groups are: Control group; Mathematics self-efficacy intervention group; and Combined mathematics self-efficacy and theory-of-intelligence interventions group. Error bars denote standard errors of the estimates.

The mean mathematics achievement standardised scores for the three groups at each time point are shown in the bottom graph in Figure 6.1. Again, time had a significant effect on the mean outcome for each group; $F(2, 298) = 62.57$, $p < .001$, as did treatment group; $F(2, 149) = 3.97$, $p = .02$. There was evidence that mathematics achievement was influenced by a significant interaction between time and treatment group; $F(4, 298) = 4.58$, $p < .001$. Compared to the Control group's mean change in achievement from Time 1 to Time 3, there was a fairly large effect size of .74 for the Mathematics self-efficacy intervention group, supporting the hypothesis that the latter would have a greater increase in mathematics self-efficacy than the former. Compared to the Control group, the Combined

interventions group showed a moderate effect size; Cohen's d = .44, evidence that supported the hypothesis that this group would also show a greater achievement gain than the Control group.

Although all groups showed an increase in mean achievement from Time 1 to Time 2, the Control group's mean decreased markedly at Time 3, and the Combined interventions group showed a slight decrease. The only treatment that did not appear to lose any ground, and in fact made a slight gain at Time 3, was the Mathematics self-efficacy intervention group. This group's mean achievement score was significantly below the Control and Combined groups' means at Time 1; $t(89) = 2.48$, $p = .02$, and $t(100) = 2.68$, $p = .01$, respectively, and at Time 2; $t(89) = 2.48$, $p = .02$, $t(100) = 3.35$, $p = .001$, respectively. At Time 3, though, this difference was no longer evident. Instead, a weak difference between the Combined interventions group and the Control group emerged; $t(109) = 1.79$, $p = .08$. Despite the drop in the Combined interventions group's Time 3 achievement score, this group still showed the highest mean achievement score on all three occasions.

Summary of between-treatment group differences

Most noticeably, the analysis of differences between treatment groups showed that at the end of the study the Mathematics self-efficacy intervention group had made significant gains in mathematics self-efficacy and achievement, compared to the Control group and the Combined interventions group. This supported the hypothesised changes for self-efficacy and achievement for the Mathematics self-efficacy intervention group and provided evidence of the effectiveness of the mathematics self-efficacy intervention. It seems likely that there was an initial implicit effect of the mathematics self-efficacy intervention that impacted on mathematics achievement in the Mathematics self-efficacy intervention group at Time 2, which in turn resulted in a more explicit effect on students' self-efficacy at Time 3.

In contrast, there was no clear evidence of the effect of the theory-of-intelligence intervention on outcomes for students in the Combined interventions group. The trajectory for theory-of-intelligence for the Combined group was not significantly different from those of the other groups, providing no support for the hypothesised changes in this variable. Neither was there evidence to support the hypothesised difference between mathematics self-efficacy and achievement of the Combined

interventions group and the two other groups at the end of the study. In the Combined interventions group, the theory-of-intelligence intervention may in fact have interfered with the self-efficacy intervention.

Differences according to gender

Between-treatment group differences for girls and boys

> *Among treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of gender?*

To identify any effects of being in different treatment groups for girls and boys, data were split by gender, and repeated-measures analyses of variance were conducted with time (three levels) the within-subjects factor, and treatment (three levels) the between-subjects factor. Figure 6.2 shows girls' mean scores for mathematics self-efficacy, theory-of-intelligence, and achievement, according to time and treatment group. Apart from the effect of time, there was no evidence of a main effect of treatment group for any of the three measures.

For girls' mathematics self-efficacy (shown in the top left graph in Figure 6.2), there was a main effect of time; $F(2, 170) = 15.96$, $p < .001$, but no effect of treatment was indicated; $F(2, 85) = 1.36$, $p = .26$. There was no significant interaction between time and treatment group; $F(4, 170) = 1.02$, $p = .40$. At Time 2, the mean self-efficacy of the Mathematics self-efficacy intervention group was very slightly lower than it was at Time 1, and was significantly lower than that of the Control and Combined interventions groups; $t(51) = 2.16$, $p = .04$, and $t(54) = 1.79$, $p = .03$, respectively.

Girls' theory-of-intelligence showed a main effect of time; $F(2, 170) = 6.11$, $p = .01$, but there was neither a main effect of treatment; $F(2, 85) = 1.41$, $p = .25$, nor an interaction effect; $F(4, 170) = 1.60$, $p = .18$. Time 1 theory-of-intelligence for girls in the Control group was significantly different from means of girls in the Mathematics self-efficacy intervention group and the Combined interventions group; $t(51) = 1.97$, $p = .05$, and $t(65) = 2.42$, $p = .02$, respectively.

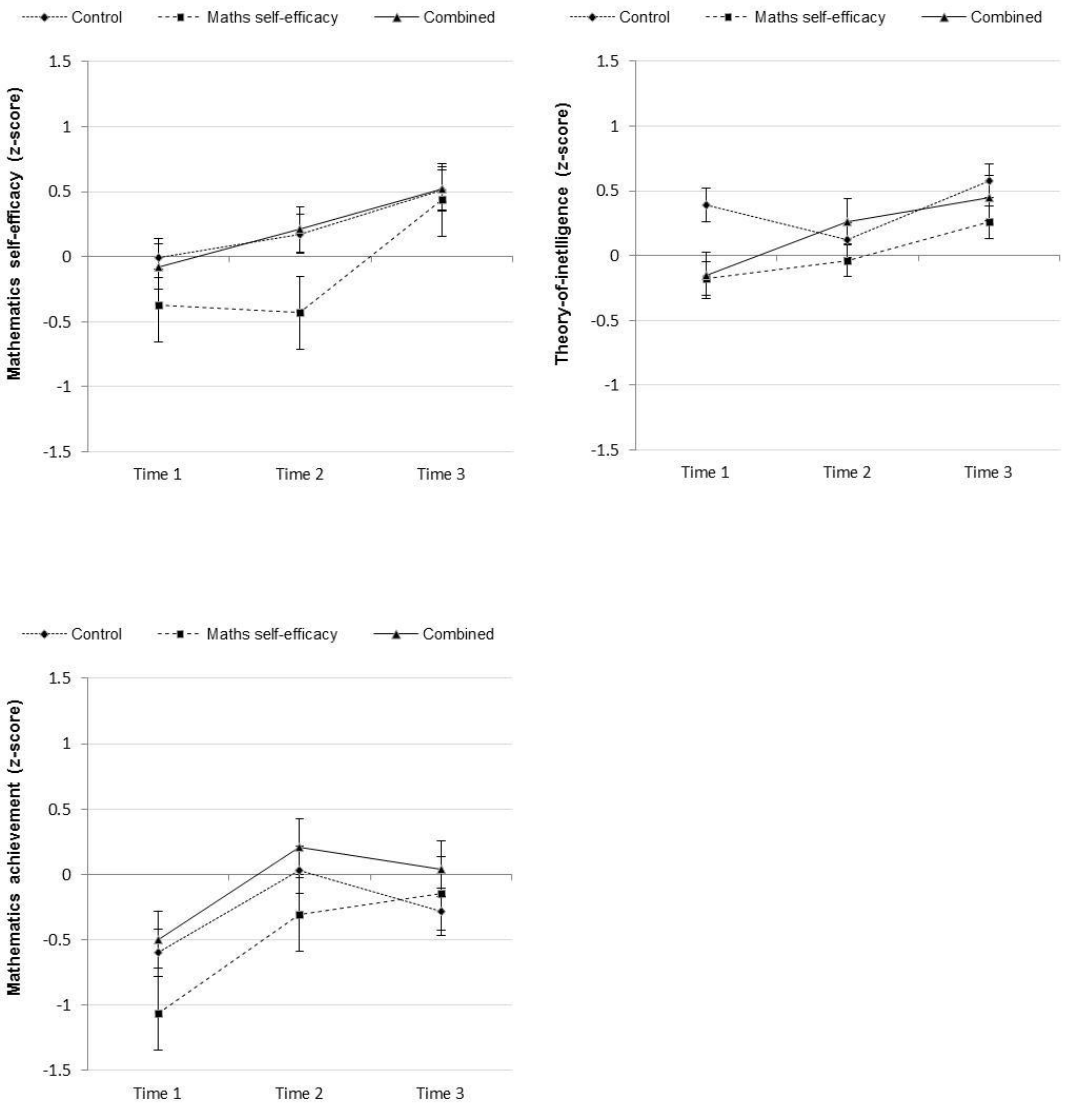


Figure 6.2. Girls' (n = 88) mean standardised scores for mathematics self-efficacy (top left), theory-of-intelligence (top right), and mathematics achievement (bottom), by time and treatment group: Control group; Mathematics self-efficacy intervention group; and Combined mathematics self-efficacy and theory-of-intelligence interventions group. Error bars denote standard errors of estimates.

For girls' mathematics achievement, a main effect of time was also indicated; $F(2, 85) = 33.96$, $p < .001$, but again, there was no main effect of treatment group; $F(2, 85) = 1.66$, $p = .20$. No significant interaction effect was shown; $F(4, 170) = 1.87$, $p = .12$. Mean achievement for girls in the Mathematics self-efficacy intervention group increased slightly from Time 2 to Time 3, whereas mean achievement for the two other groups decreased slightly.

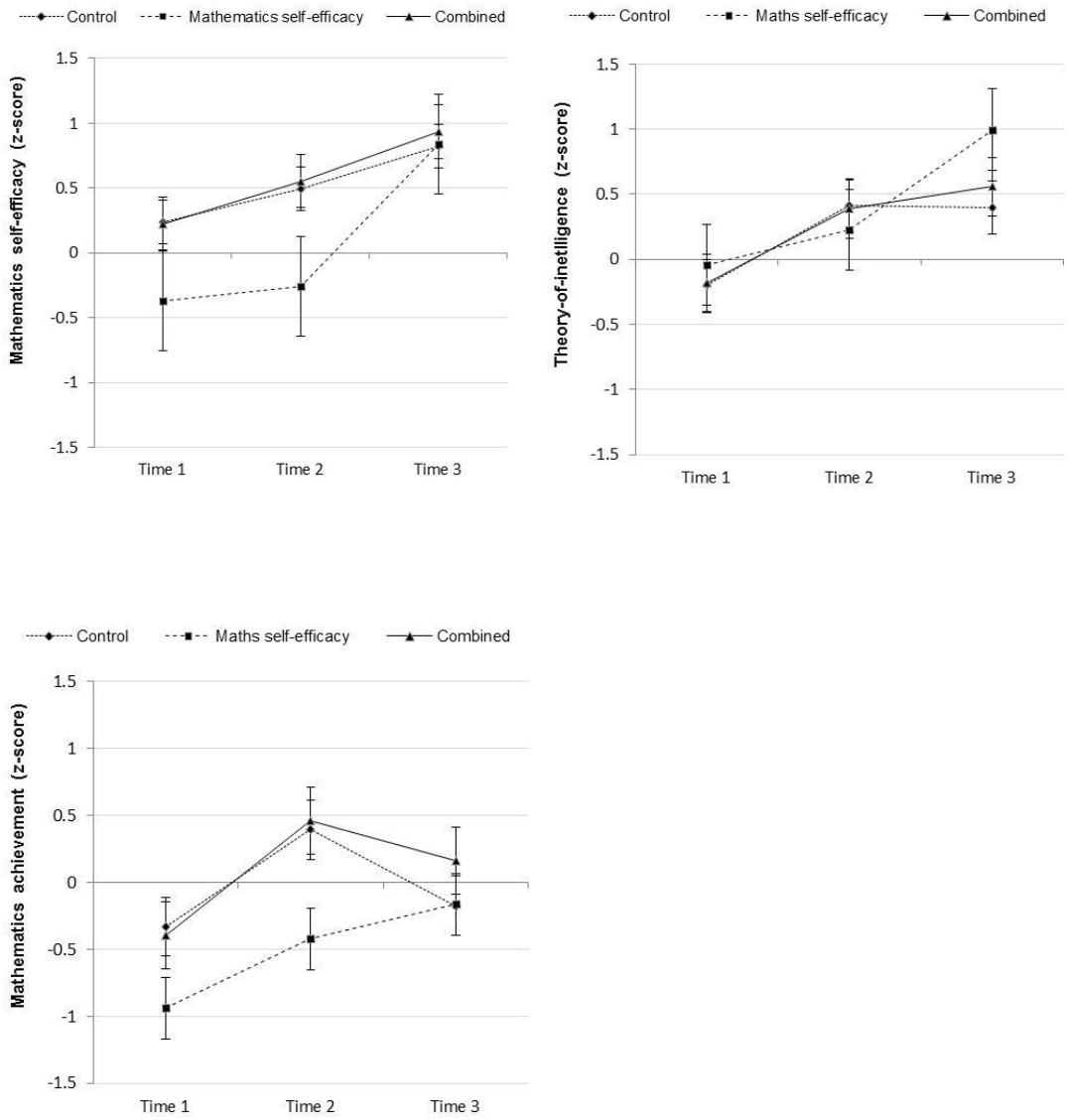


Figure 6.3. Boys' (n = 64) mean standardised scores for mathematics self-efficacy (top left), theory-of-intelligence (top right), and mathematics achievement (bottom), by time and treatment group: Control group; Mathematics self-efficacy intervention group; and Combined mathematics self-efficacy and theory-of-intelligence interventions group. Error bars denote standard errors of estimates.

Boys' mean scores for mathematics self-efficacy, theory-of-intelligence, and achievement are shown in Figure 6.3, by time and treatment group. For boys' mathematics self-efficacy (shown in the first graph in Figure 6.3), there was a significant main effect of time; $F(2, 122) = 35.20$, $p < .001$, and a very marginal effect of treatment; $F(2, 61) = 2.85$, $p = .07$, which approached the .05 significance threshold. Also evident was a significant interaction between time and treatment; $F(4, 122) = 3.11$, $p = .02$. Boys in the Mathematics self-efficacy intervention group ($n = 20$) had significantly lower mean mathematics self-efficacy than boys in the Combined interventions groups at Times 1; $t(44) = 2.06$, $p = .05$, and Time 2; $t(44) = 2.93$, $p = .01$, and significantly lower self-efficacy than boys in the Control

group at Time 2; $t(36) = 2.25$, $p = .03$. An increase in mean self-efficacy of boys in the Mathematics self-efficacy intervention group at Time 3 resulted in no significant differences in mean self-efficacy for boys in the three treatment groups at the final time point. The change in mean self-efficacy of boys in the Mathematics self-efficacy intervention group from Times 1 to 3 indicated a large effect size compared to that of boys in the Control group; Cohen's $d = .79$.The second graph in Figure 6.3 shows boys' theory-of-intelligence by treatment group. A main effect of time was evident; $F(2, 122) = 14.43$, $p < .001$, but there was no main effect of treatment group; $F < 1$. Neither was there a significant interaction between time and treatment; $F(4, 122) = 1.21$, $p = .31$. Mean scores for boys' theory-of-intelligence increased for all groups from Time 1 to Time 3.

For boys' mathematics achievement (the last graph in Figure 6.3), a main effect of time was indicated; $F(2, 122) = 28.84$, $p < .001$. A main effect of treatment group was beyond the significance threshold of .05; $F(2, 61) = 2.54$, $p = .09$. A significant interaction between time and treatment was evident; $F(4, 122) = 3.53$, $p = .01$. For boys in the Mathematics self-efficacy intervention group, mean achievement was significantly below that of boys in the two other groups at Times 1 and 2. At Time 3, no significant differences between boys in the three groups persisted, partly due to an increase in self-efficacy for the Mathematics self-efficacy intervention group, and partly due to decreases in mean self-efficacy for boys in the two other groups. A large effect size (Cohen's $d = .74$) was evident for mean change in achievement from Time 1 to Time 3 for the Mathematics self-efficacy intervention group, compared to mean achievement change for the Control group. Because there seemed to be some similarity in the trajectories for self-efficacy and achievement for boys in the Mathematics self-efficacy intervention group, the changes in boys' self-efficacy and achievement from Time 1 to Time 3 were compared to see if they might be correlated for this treatment group, but no significant correlation was evident; $r = .09$, $p = .70$.

Summary of between-treatment group differences for girls and boys

Time was the only significant effect on girls' mathematics self-efficacy, theory-of-intelligence, and achievement, each of which increased for all groups from Time 1 to Time 3. For boys, mathematics self-efficacy and achievement were both affected by significant interactions between time and treatment. Boys in the Mathematics self-efficacy intervention group had significantly lower mean mathematics self-

efficacy and achievement than those of boys in the two other groups at Times 1 and 2. At Time 3, though, their mean scores no longer differed significantly.

Within-treatment group differences for boys and girls

> *Within treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of gender?*

Each treatment group's mean scores for mathematics self-efficacy for boys and girls are shown in Figure 6.4.

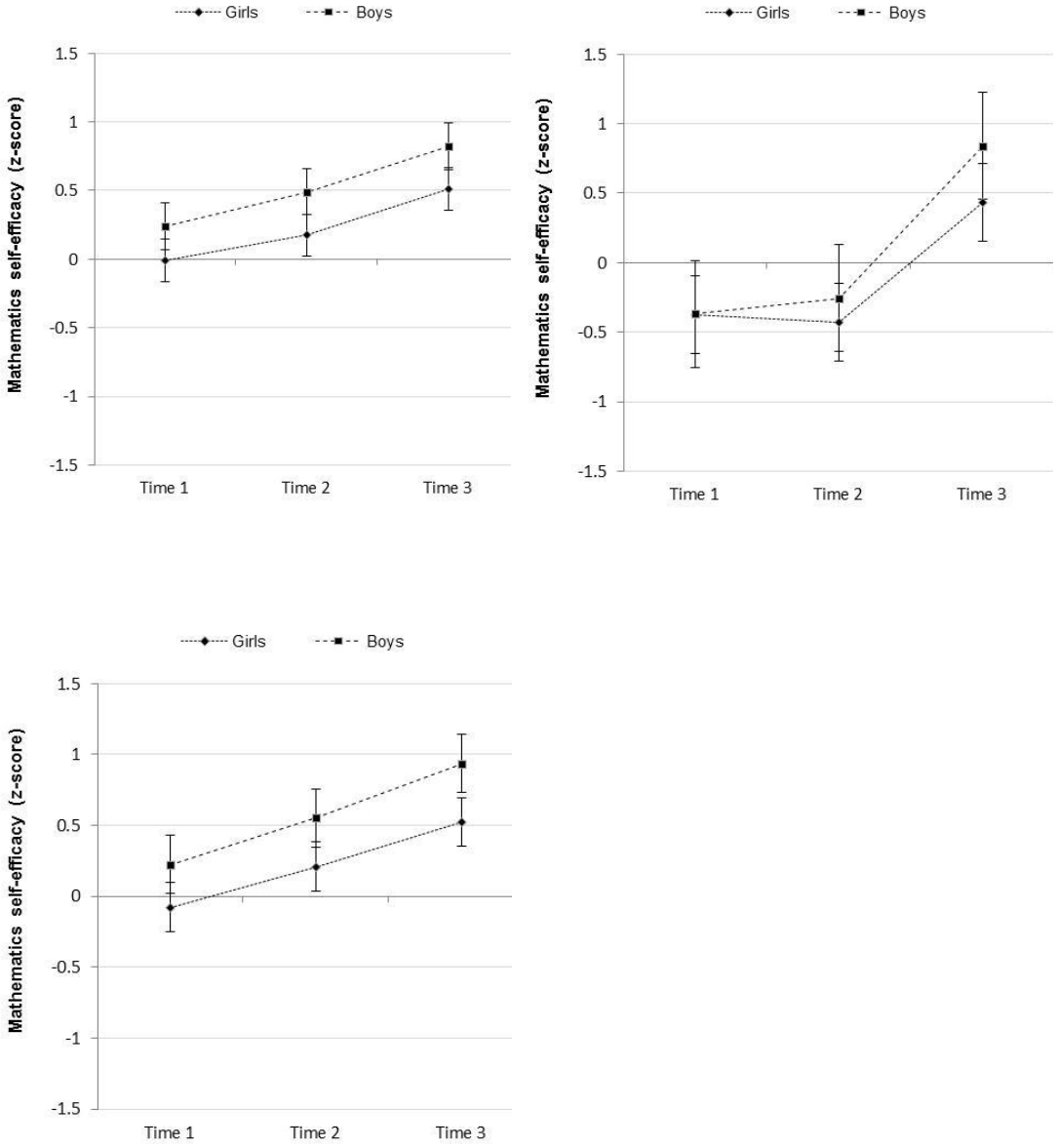


Figure 6.4. Treatment groups' mathematics self-efficacy by time and gender. Treatment groups are: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

In each treatment group, time had a main effect on students' mathematics self-efficacy, and although boys' mean scores appeared to be higher than girls', no gender difference reached the significance threshold of $p < .05$. For the Control group, a main effect of time was indicated; $F(2, 96) = 7.30$, $p < .001$, but no main effect of gender was evident; $F(1, 48) = 1.61$, $p = .21$. Nor was there a significant interaction between time and gender: $F < 1$. A main effect of time on self-efficacy was also evident for the Mathematics self-efficacy intervention group; $F(2, 78) = 19.76$, $p < .001$, but there was no effect of gender, and no interaction effect; $F < 1$ in both cases. Likewise, there was a main effect of time for the Combined interventions group; $F(2, 118) = 17.89$, $p < .001$, but no main effect of gender; $F(1, 59) = 3.07$, $p = .09$. Neither was the interaction between time and gender significant; $F < 1$.

Figure 6.5 shows mean theory-of-intelligence scores for each treatment group, by gender. In the Control group's theory-of-intelligence (see the top left graph in Figure 6.5), there was a main effect of time; $F(2, 96) = 2.86$, $p = .06$, but gender alone had no significant effect; $F < 1$. A significant interaction between gender and time was evident; $F(2, 96) = 3.64$, $p = .03$. Boys in this group ($n = 18$) had a significantly lower mean theory-of-intelligence than girls ($n = 32$) at Time 1; $t(48) = 2.06$, $p = .05$, but at Time 2 the effect of gender was no longer significant. In the Mathematics self-efficacy intervention group, a significant main effect of time on theory-of-intelligence was indicated; $F(2, 78) = 8.77$, $p < .001$. There was neither a main effect of gender; $F(1, 39) = 2.31$, $p = .14$, nor an interaction effect; $F(2, 78) = 1.54$, $p = .22$. At Time 3, however, boys in the Mathematics self-efficacy intervention group had a significantly higher mean theory-of-intelligence than girls; $t(39) = 2.00$, $p = .05$.

A main effect of time on the Combined interventions group's theory-of-intelligence was evident; $F(2, 118) = 10.95$, $p < .001$, but no main effect of gender, or interaction between time and gender, was indicated; $F < 1$ in both cases. Of the three treatment groups, the greatest similarity of girls' and boys' theory-of-intelligence scores was in the Combined interventions group.

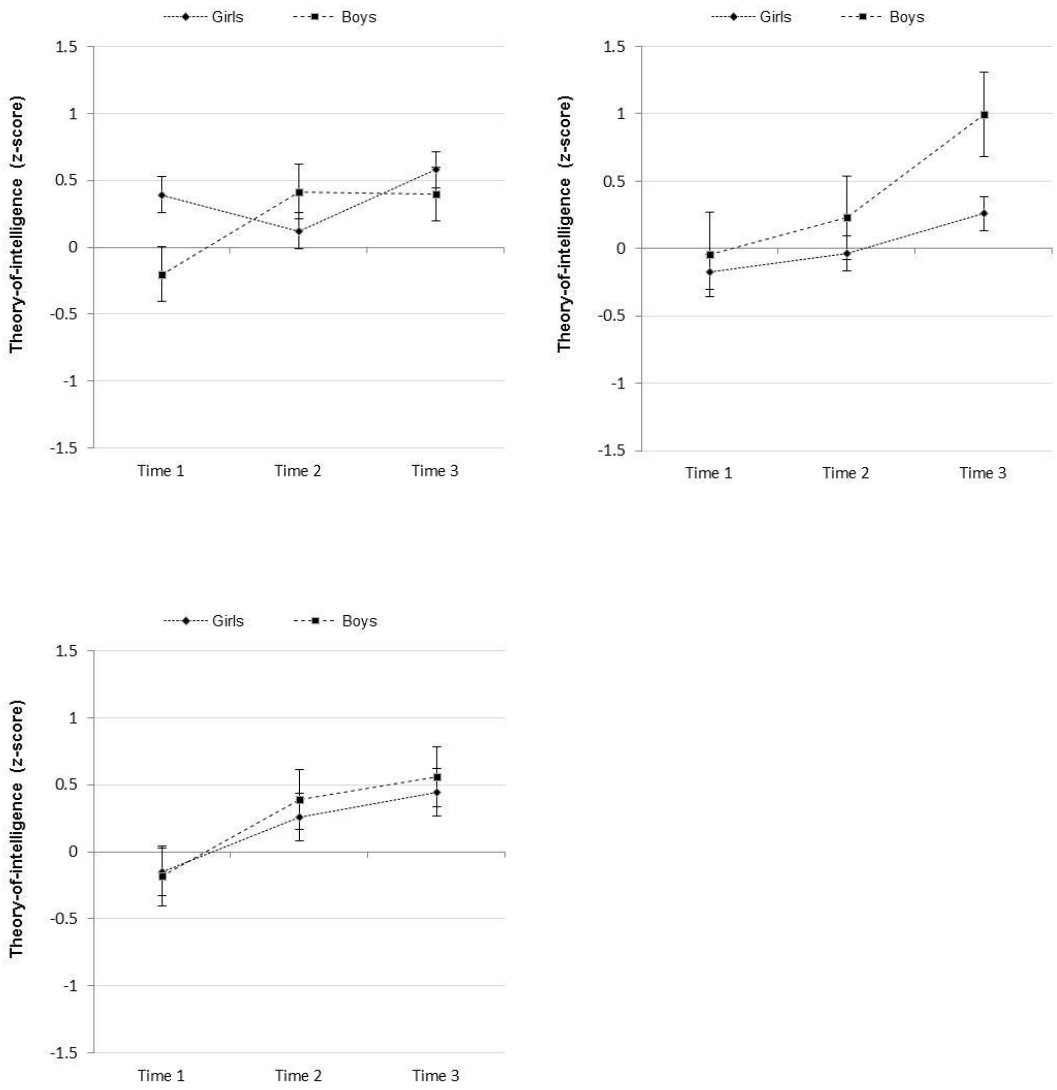


Figure 6.5. Treatment groups' mean standardised scores for theory-of-intelligence, by time and gender. Treatment groups are: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

Figure 6.6 shows mean mathematics achievement scores for each treatment group by time and gender. Importantly, no significant effect of gender on students' achievement was found for any treatment group. The graphs for the Control group and the Combined interventions group both show decreases in girls' and boys' mean achievement from Time 2 to Time 3, and in both groups, boys' mean achievement is very slightly greater than that of girls. In the Mathematics self-efficacy intervention group, increases in mean achievement were shown for boys and girls alike, with scores for both genders very similar.

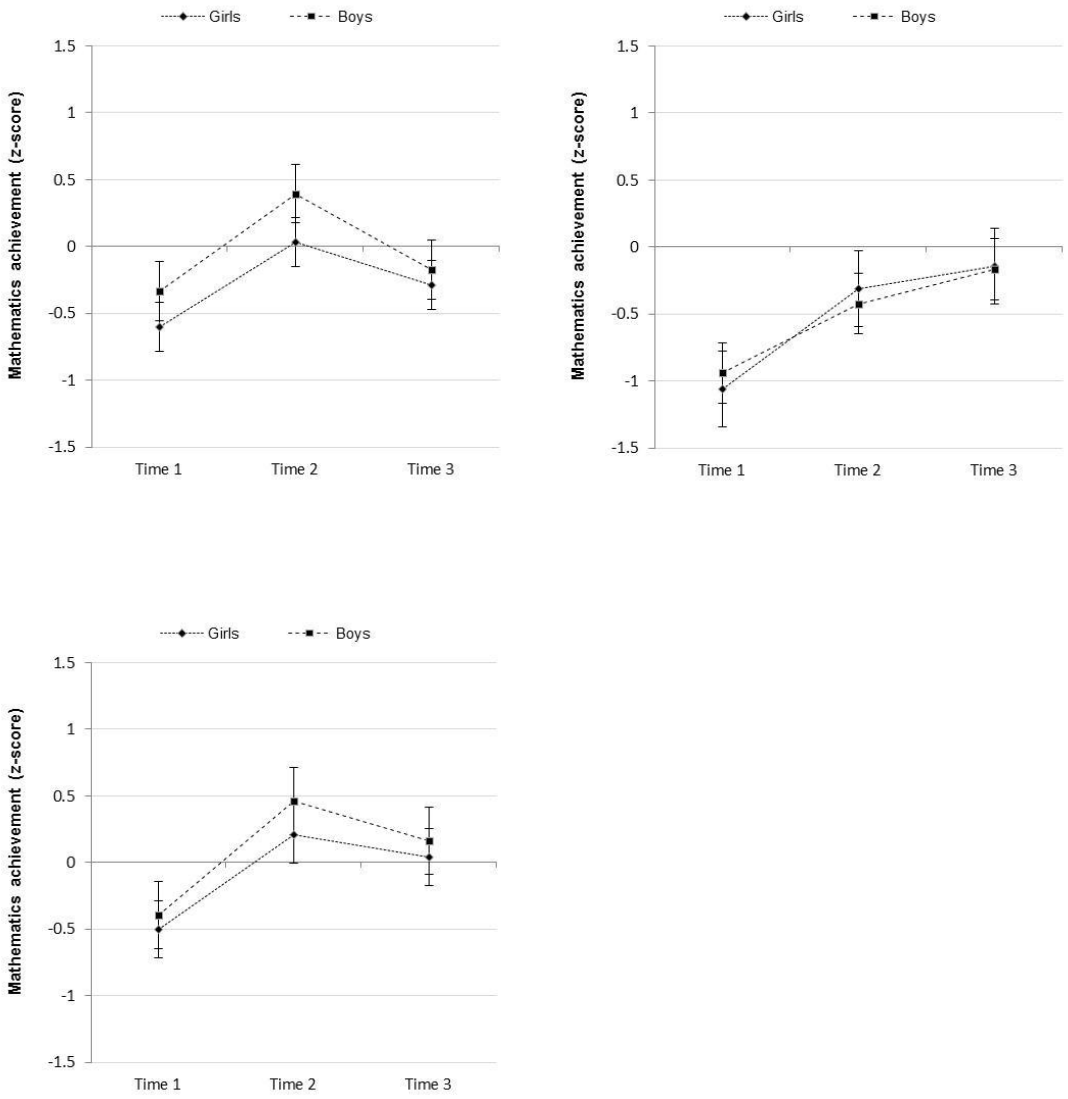


Figure 6.6. Treatment groups' mean standardised scores for mathematics achievement, by time and gender. Treatment groups are: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

For the Control group's achievement, a main effect of time was evident; $F(2, 96) = 15.88$, $p < .001$, but there was no main effect of gender; $F(1, 48) = 1.19$, $p = .28$. The Mathematics self-efficacy intervention group also showed a main effect of time; $F(2, 78) = 19.93$, $p < .001$; but no main effect of gender; $F < 1$. For the Combined interventions group, there was a main effect of time on achievement; $F(2, 118) = 38.94$, $p < .001$, but again, there was no main effect of gender; $F < 1$. Interaction effects for each group did not reach the significance threshold; $F < 1$ in each case.

Summary of within-treatment group differences for boys and girls

Overall, mean scores for mathematics self-efficacy, theory-of-intelligence, and achievement increased from Time 1 to Time 3 for all treatment groups, for boys and for girls. In the Control group, an initial significant difference between the boys' and girls' mean scores for theory-of-intelligence was no longer evident at Time 2. In contrast, boys' mean theory-of-intelligence was significantly greater than girls' theory-of-intelligence at Time 3 only, for the Mathematics self-efficacy intervention group. For boys in the Mathematics self-efficacy intervention group, mean mathematics self-efficacy and achievement at Times 1 and 2 were significantly lower than those of boys in the two other groups. At Time 3, these significant differences were no longer evident.

Differences according to year level

> *Among treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of year level?*

Between-treatment group differences for Year 4 and 5 students

To identify any effects of being in different treatment groups for Year 4 and 5 students, data were split by year level, and repeated-measures analyses of variance were conducted with time (three levels) the within-subjects factor, and treatment (three levels) the between-subjects factor. Figure 6.7 shows Year 4 students' mean scores for mathematics self-efficacy, theory-of-intelligence, and achievement, according to time and treatment group.

For Year 4 students, a main effect of time on mathematics self-efficacy was evident (see the top left graph in Figure 6.7); $F(2, 110) = 16.06$, $p < .001$; there was no significant effect of treatment group; $F < 1$. The interaction between time and treatment was not significant; $F(4, 110) = 1.54$, $p = .20$.

Year 4 students' theory-of-intelligence was subject to a significant main effect of time; $F(2, 110) = 10.54$, $p < .001$; but no significant effect of treatment; $F(2, 55) = 1.64$, $p = .20$, and no interaction effect; $F(4, 110) = 1.35$, $p = .26$. Mean theory-of-intelligence for Year 4 students in the Mathematics self-efficacy intervention group ($n = 12$) increased quite sharply between Time 2 and Time 3, by which point it was significantly different to the mean of the Combined interventions group $t(38) = 2.09$,

p = .04, but not significantly different to the mean of the Control group; $t(28) = 1.91$, p = .07.

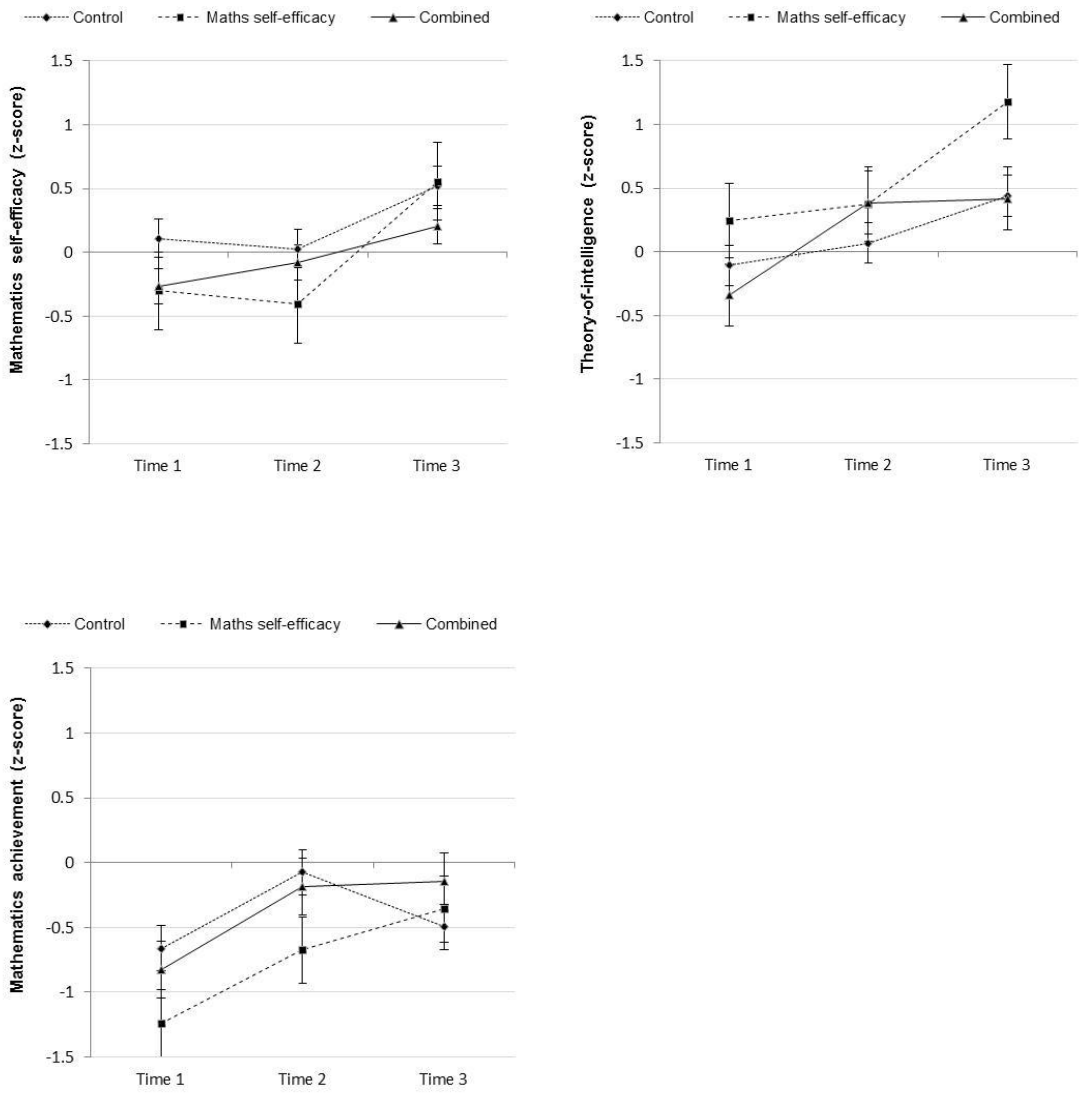


Figure 6.7. Year 4 students' mean standardised scores for mathematics self-efficacy, theory-of-intelligence, and mathematics achievement, by time and treatment group: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

Year 4 students' mathematics achievement was affected by a significant main effect of time; $F(2, 182) = 20.77$, $p < .001$, but no main effect of treatment group was evident; $F < 1$. A significant interaction between time and treatment group was indicated; $F(4, 110) = 2.58$, p = .04. The bottom graph in Figure 6.7 shows that the mean mathematics achievement of Year 4 students in the Mathematics self-efficacy intervention group was noticeably lower than that of the two other groups at Times 1 and 2, but the differences did not reach the significance threshold of .05. When mean change in achievement from Times 1 to 3 was compared between the

Mathematics self-efficacy intervention group and the Control group, an effect size was shown; Cohen's *d* = 1.09. This was in part due to a decrease in mean achievement for Year 4 students in the Control group from Time 2 to Time 3, which resulted in a very small net gain of .16 logits from Time 1 to Time 3.

Year 5 students' mathematics self-efficacy, theory-of-intelligence, and achievement scores are shown in Figure 6.8.

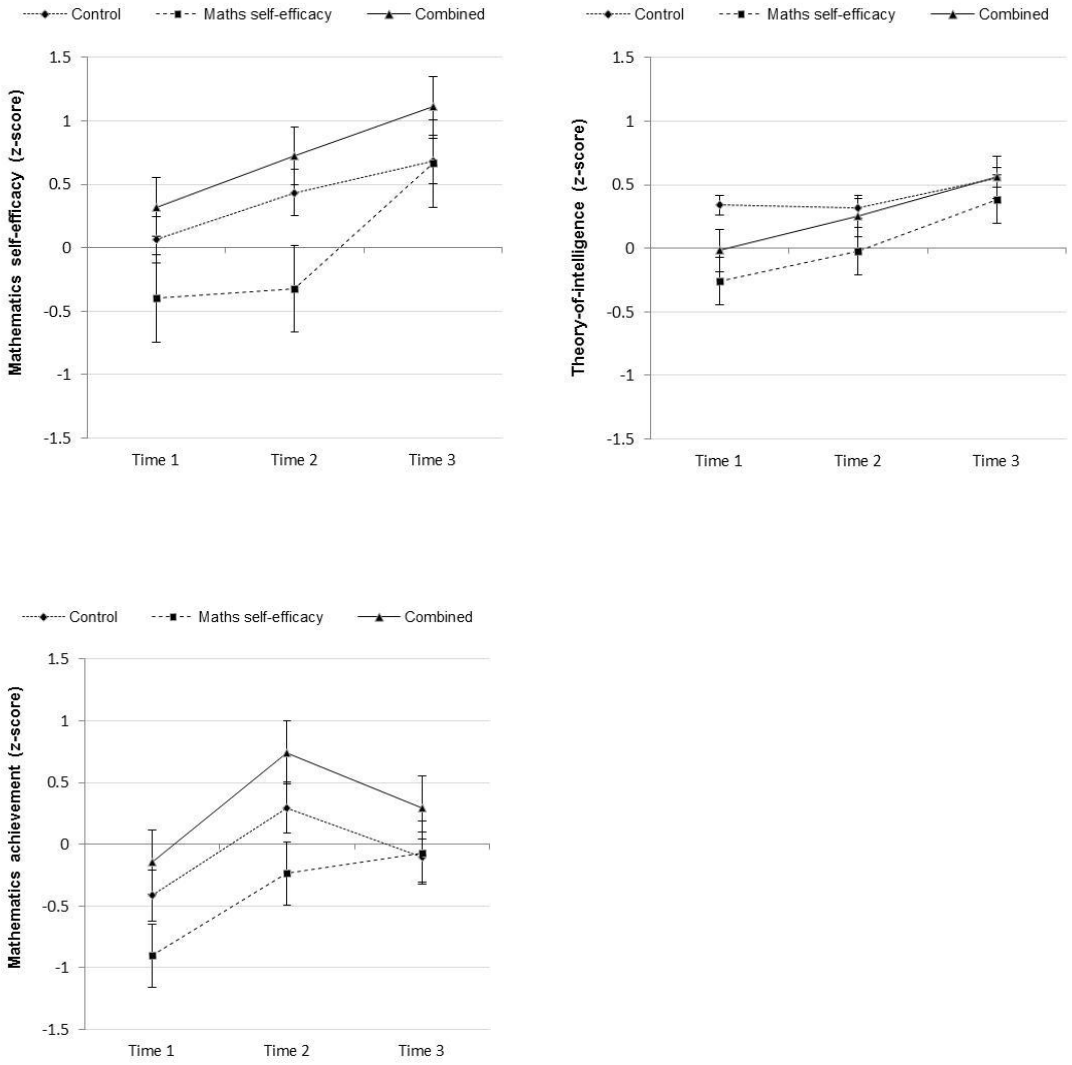


Figure 6.8. Year 5 students' mean standardised scores for mathematics self-efficacy, theory-of-intelligence, and mathematics achievement, by time and treatment group: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

Main effects of time; $F(2, 182) = 29.54$, $p < .001$; and treatment; $F(2, 91) = 6.49$, $p = .01$, were indicated for Year 5 students' mathematics self-efficacy. An interaction between time and treatment was beyond the .05 significance threshold; $F(4, 182) = 2.11$, $p = .08$. Once again, the lower Times 1 and 2 mathematics self-efficacy of a sub-sample of the Mathematics self-efficacy intervention group – in

this instance, Year 5 students – was evident. At Time 2, their self-efficacy was significantly lower than that of Year 5 students in the Control and Combined interventions groups; $t(59) = 2.83$, $p = .01$, and $t(60) = 4.22$, $p < .001$, respectively.

For Year 5 students' theory-of-intelligence, the only significant effect was that of time; $F(2, 182) = 8.53$, $p < .001$. There was no significant effect of treatment group; $F(4, 182) = 2.01$, $p = .14$, and no interaction effect; $F < 1$.

For Year 5 students' achievement, main effects of time; $F(2, 182) = 41.90$, $p < .001$, and treatment; $F(2, 91) = 5.47$, $p = .01$, were indicated. A significant interaction between time and treatment group was also evident; $F(2, 182) = 3.08$, $p = .02$. Again, the significantly lower mean achievement of Year 5 students in the Mathematics self-efficacy intervention group at Times 1 and 2 is shown, with no significant differences between the groups' Time 3 means. Mean change in achievement from Time 1 to Time 3 was compared between Year 5 students in the Mathematics self-efficacy group and the Control group, and a moderate effect size was identified; Cohen's $d = .61$.

Summary of between-treatment group differences for Year 4 and 5 students

Time had a significant effect on all three mean measures for students in all treatment groups. For Year 4 students, a significant interaction between time and treatment was evident for mathematics achievement, with those in the Mathematics self-efficacy intervention group having lower mean achievement than Year 4 students in the two other groups until Time 3. For Year 5 students in the Mathematics self-efficacy intervention group, this between-group difference in mean achievement was more clearly defined, with significant effects of time and treatment group, and significant interaction effects, for mathematics self-efficacy and achievement. For both measures, any significant between-group differences were no longer evident at Time 3.

Within-treatment group differences for Year 4 and 5 students

Within treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of year level?

Each treatment group's mean scores for mathematics self-efficacy are shown by year level in Figure 6.9. Perhaps most striking is the lack of similarity between the graphs.

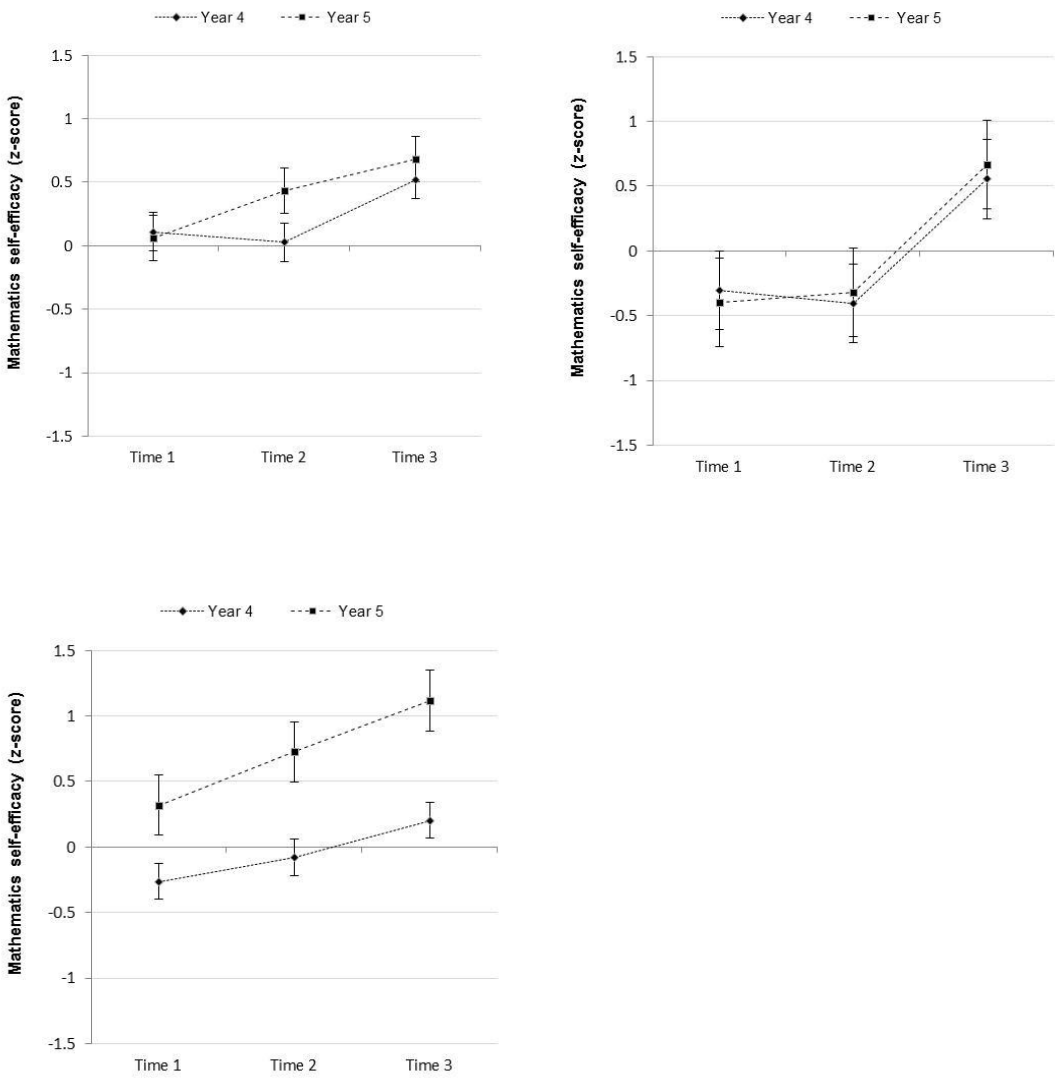


Figure 6.9. Treatment groups' mathematics self-efficacy by time and year level. Treatment groups are: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

A main effect of time on self-efficacy of the Control group students was indicated; $F(2, 96) = 6.80$, $p = .01$. No main effect of year level was evident; $F < 1$, and neither was there a significant interaction; $F(2, 96) = 1.24$, $p = .29$. At Time 2, the

difference between Year 4 and Year 5 students' mean self-efficacy was not significant; t (48) = 1.51, p = .14.

For the Mathematics self-efficacy intervention group, a main effect of time was also indicated; F(2, 78) = 15.30, p < .001, but there was neither a significant effect of year level nor an interaction effect; F < 1 in both cases. Mean scores for the two year levels were in fact very similar in this treatment group, with both increasing sharply at Time 3.

The Combined interventions group showed a main effect of year level; F(1, 59) = 18.43, p < .001, as well as a main effect of time; F(2, 118) = 17.29, p < .001. There was no significant interaction between time and year level; F(2, 118) = 1.20, p = .31. For the Combined interventions group, Year 5 students had significantly greater mean self-efficacy scores than Year 4 students at all three time points; t(59) = 2.68, p = .01 at Time 1, t(59) = 3.93, p < .001 at Time 2, and t(59) = 3.98, p < .001 at Time 3.

Figure 6.10 shows each treatment group's theory-of-intelligence scores by time and year level. For the Control group (see the top left graph), the main effect of time was beyond the .05 significance threshold; F(2, 96) = 2.82, p = .07. Neither was there a significant effect of year level; F(1, 48) = 1.56, p = .22. No significant interaction was evident; F < 1. At Time 1, Year 5 students' mean theory-of-intelligence was greater than the mean theory-of-intelligence of Year 4 students in the Control group, but this was non-significant; t(48) = 1.52, p = .14.

In contrast to the Control group, where Year 5 students had higher mean theory-of-intelligence than Year 4 students, the reverse was evident in the Mathematics self-efficacy intervention group. Main effects of time; F(2, 78) = 8.35, p = .01, and year level; F(1, 39) = 4.497, p = .04, were indicated for the Mathematics self-efficacy intervention group. No interaction between time and year level was evident; F < 1. Year 4 students' mean theory-of-intelligence was greater than that of Year 5 students at each time point for this treatment group, but did not reach the significance threshold even at Time 3, when the difference appeared greatest; t(39) = 1.94, p = .06.

The only significant effect on the Combined interventions group's theory-of-intelligence was time; F(2, 118) = 11.30, p < .001. There was no significant effect of year level; F < 1, and no significant interaction of time and year level;

$F(2, 118) = 1.24$, $p = .29$. In all treatment groups, Year 4 and 5 students' mean theory-of-intelligence scores were greater at Time 3 than at Time 1.

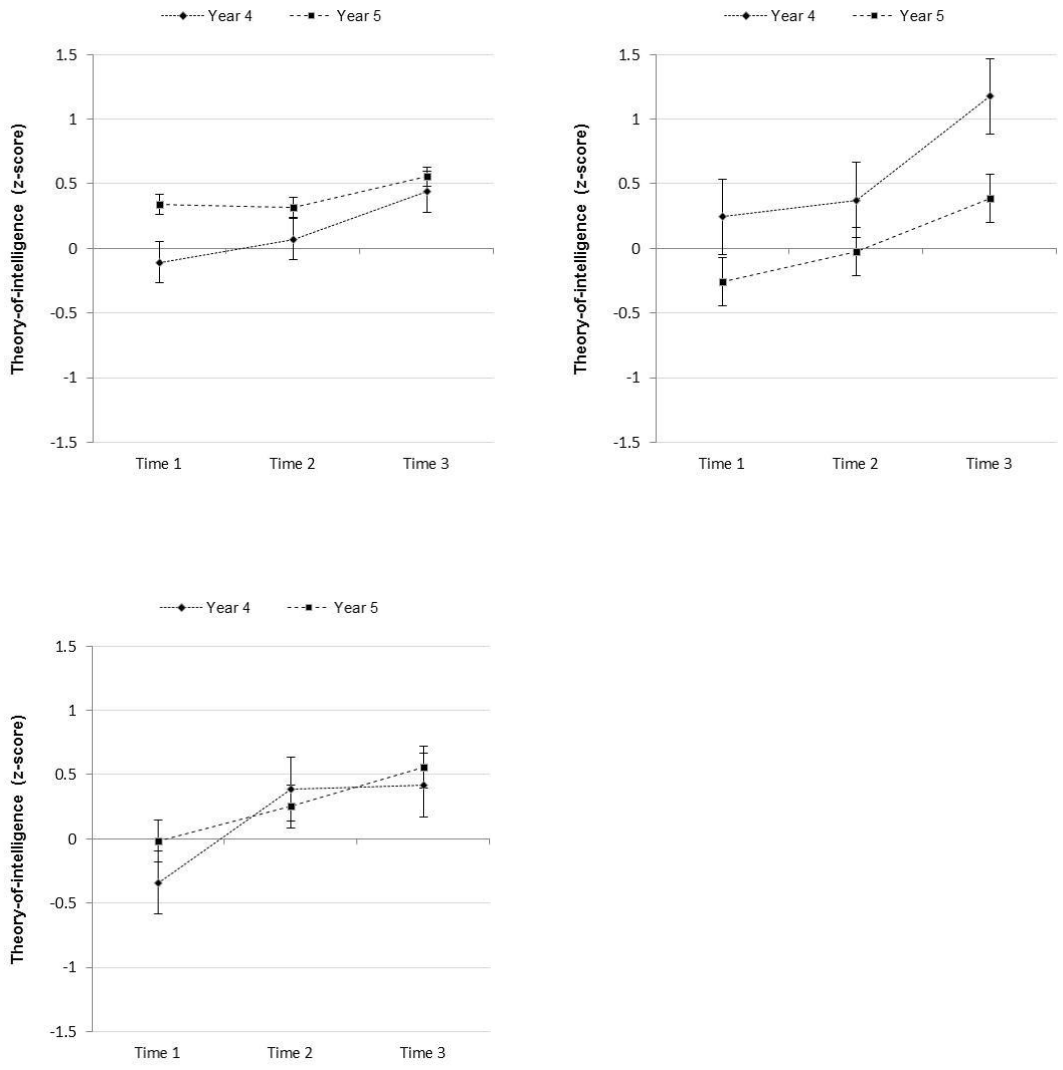


Figure 6.10. Treatment groups' theory-of-intelligence by time and year level. Treatment groups are: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

Figure 6.11 shows each treatment group's mathematics achievement, by time and year level. In all three graphs, the mean achievement of Year 5 is greater than that of Year 4. For the Control group and the Mathematics self-efficacy intervention group, time was the only significant effect: $F(2, 96) = 14.30$, $p < .001$, and $F(2, 78) = 16.56$, $p < .001$, respectively. Year level had no significant effect on achievement in the Control group; $F(1, 48) = 2.27$, $p = .14$, or in the Mathematics self-efficacy intervention group; $F(1, 39) = 1.37$, $p = .25$. No interaction effects were indicated; $F < 1$ for both groups.

For the Combined interventions group, main effects of time; $F(2, 118) = 40.24$, $p < .001$, and year level were evident; $F(1, 59) = 9.40$, $p = .01$, along with a significant interaction between year level and time; $F(2, 118) = 3.79$, $p = .03$. Mean achievement of Year 5 students in this group was significantly greater than that of Year 4 students at Time 1; $t(59) = 2.74$, $p = .01$, and at Time 2; $t(59) = 4.24$, $p < .001$.

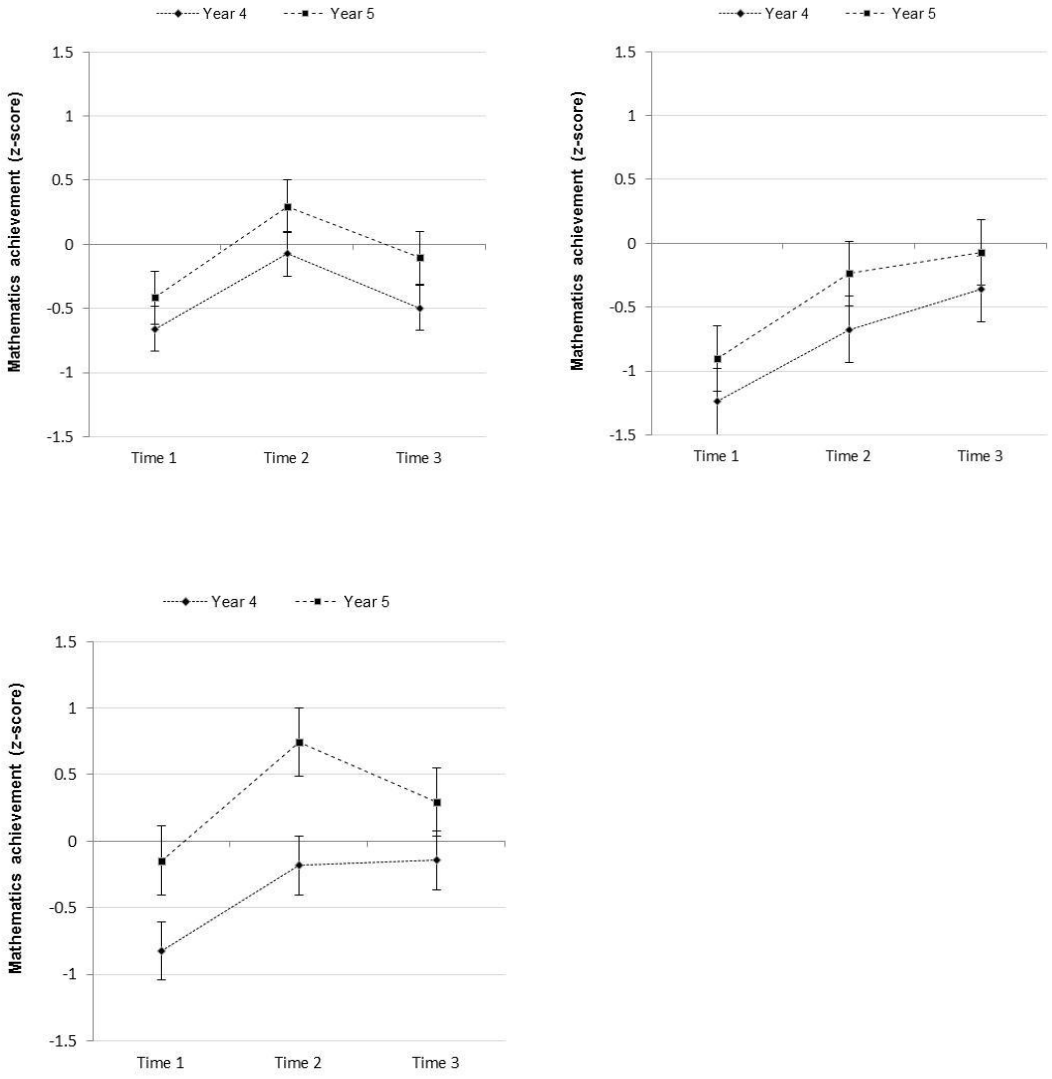


Figure 6.11. Treatment groups' mathematics achievement by time and year level. Treatment groups are: Control group (top left); Mathematics self-efficacy intervention group (top right); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Error bars denote standard errors of estimates.

Summary of within-treatment group differences according to year level

Most of the significant differences associated with year level were related to mathematics self-efficacy and achievement. The mean achievement of Year 4 (at Time 2) and Year 5 students (at Times 1 and 2) in the Mathematics self-efficacy

intervention group was significantly lower than that of their peers in the two other groups. In the Combined interventions group, Year 5 students had significantly greater mathematics self-efficacy (at Times 1, 2, and 3) and achievement (at Times 1 and 2) than Year 4 students in this treatment group. Significant differences according to year level for theory-of-intelligence were indicated for the Mathematics self-efficacy intervention group, in which the mean for Year 4 students exceeded that of Year 5 students, and time had a significant effect. Time also had a significant effect on the Combined group's mean theory-of-intelligence, but year level showed no significant effect. Mean theory-of-intelligence scores for Year 4 and 5 students in all groups were higher at Time 3 than Time 1.

Correlations between measures, according to treatment group

> *How are students' theory-of-intelligence, mathematics self-efficacy, and mathematics achievement related?*

Correlations between self-efficacy, theory-of-intelligence, and mathematics achievement at Times 1, 2, and 3 are shown for the three treatment groups in Table 6.3. Consistent across all treatment groups' data – including the Control group's – were significant, moderate-to-strong correlations between mathematics self-efficacy and achievement (for statistically significant correlations, r ranged from 0.31, $p < .05$, to 0.73, $p < .01$). Correlations between the three self-efficacy measures were all statistically significant, as were correlations between the three achievement measures, with the latter including some strong associations (up to $r = 0.78$, $p < .01$). In the correlations between mathematics self-efficacy and achievement, the strength of the Time 2 correlation for the Mathematics self-efficacy intervention group is almost four times the variance explained at Time 1 ($r^2 = .46$ and $r^2 = .12$, $p < .01$ and $p = .03$, respectively).

Measures of students' theory-of-intelligence had only two statistically significant correlations with achievement measures, giving little support to the hypothesis that theory-of-intelligence was associated with mathematics achievement. Significant moderate correlations between Time 2 and Time 3 theory-of-intelligence measures might be explained by students' understanding of intelligence becoming more stable as they get older. Reasons for several statistically significant moderate correlations between mathematics self-efficacy and theory-of-intelligence – particularly involving Time 3 theory-of-intelligence – could not be identified from

close examination of the quantitative data, and were further investigated in the qualitative data analysis.

Table 6.3: Significant correlations between student variables

Pearson's correlations between Year 4 and 5 students' standardised scores for theory-of-intelligence, mathematics self-efficacy, and achievement at Times 1, 2, and 3, by treatment group: Control group (top); Mathematics self-efficacy intervention group (middle); Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Note: $p < .05$ for all correlations shown; non-significant correlations are omitted.

	Mathematics self-efficacy		Theory-of-intelligence			Mathematics achievement		
	Time 2	*Time 3*	*Time 1*	*Time 2*	*Time 3*	*Time 1*	*Time 2*	*Time 3*
Mathematics self-efficacy *Time 1*	0.30 0.45 0.62	0.77 0.32 0.60	0.32		0.34 0.32	0.57 0.34 0.59	0.42 0.47	0.38 0.37
Mathematics self-efficacy *Time 2*		0.52 0.49 0.68		0.35		0.37 0.56 0.60	0.31 0.68 0.57	0.41 0.68 0.46
Mathematics self-efficacy *Time 3*				0.42	0.44	0.60 0.48 0.73	0.33 0.55 0.60	0.49 0.60 0.53
Theory-of-intelligence *Time 1*					0.33			
Theory-of-intelligence *Time 2*					0.45 0.51		0.29	0.39
Theory-of-intelligence *Time 3*								
Mathematics achievement *Time 1*							0.39 0.59 0.65	0.64 0.61 0.78
Mathematics achievement *Time 2*								0.47 0.64 0.54

A closer examination of the relationship between students' mathematics self-efficacy and achievement

At each of the three time points, students' mathematics self-efficacy and achievement logit scores were almost always significantly correlated for each group (see Table 6.3). Because self-efficacy and achievement are correlated, part of students' later achievement is associated with shared variance in earlier achievement, making it difficult to establish the nature of the relationship between the two constructs. In addition to the variance that is shared by both constructs,

variance in later achievement is also associated with unique variance in earlier achievement, and in earlier and concurrent self-efficacy.

Pairs of linear regression analyses were used to estimate the extent to which earlier achievement, earlier self-efficacy, and concurrent self-efficacy, are associated with the variance in later achievement. Figure 6.13 shows the shared and unique variance in Time 2 achievement associated with Time 1 achievement, and Time 1 and Time 2 self-efficacy for each group.

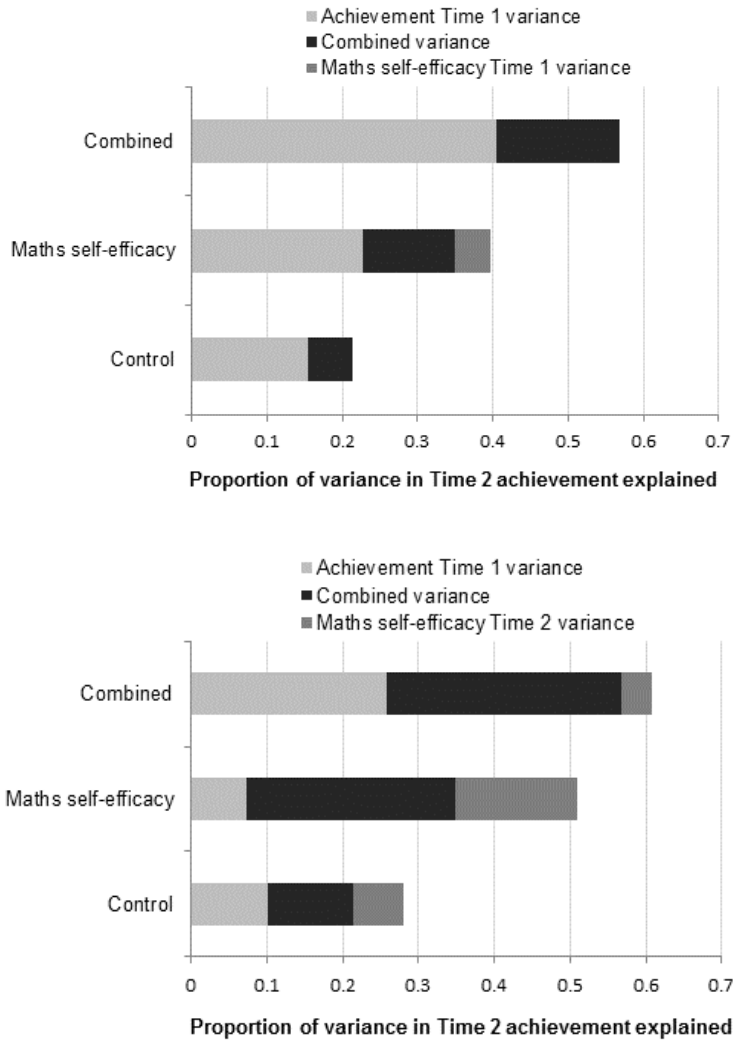


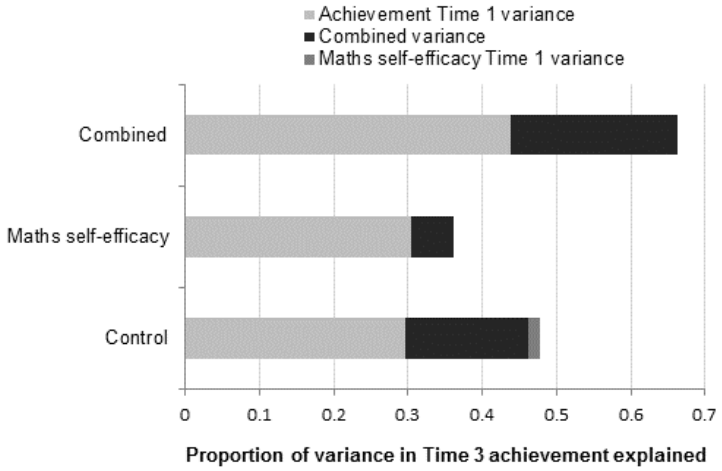
Figure 6.13. Time 2 mathematics achievement variance associated with prior achievement, and prior and concurrent self-efficacy. The top panel shows variance associated with Time 1 achievement and self-efficacy; and the bottom panel shows variance associated with Time 1 achievement and Time 2 self-efficacy. Treatment groups are: Control group; Mathematics self-efficacy intervention group (Maths self-efficacy); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (Combined).

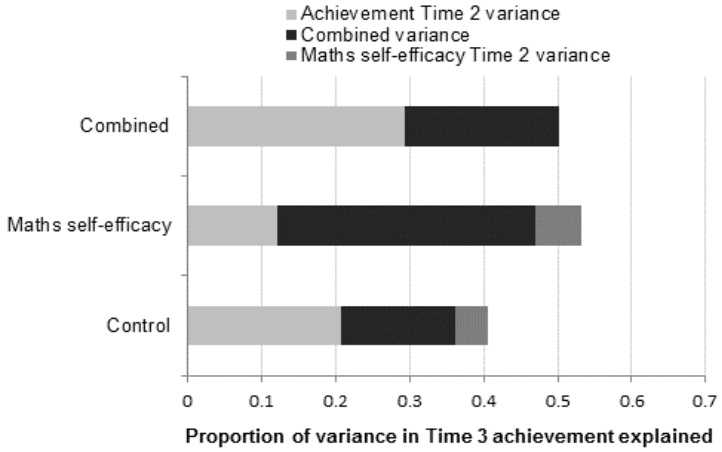
The top panel shows that in all three groups, students' Time 1 achievement was more predictive of Time 2 achievement than their Time 1 self-efficacy, which in fact

was associated with only a small proportion of unique variance in Time 2 achievement (5%) for the Mathematics self-efficacy intervention group. For the Combined interventions group, 40% of the variance in Time 2 achievement was uniquely associated with Time 1 achievement, compared with 23% for the Mathematics self-efficacy intervention group, and 16% for the Control group. A smaller proportion of variance in Time 2 achievement was associated with shared and unique variance in Time 1 self-efficacy for each group; 16% for the Combined interventions group, 17% for the Mathematics self-efficacy intervention group, and 6% for the Control group.

The bottom panel shows that, immediately post-intervention, the variance in Time 2 achievement associated with Time 2 self-efficacy is more than double that associated with Time 1 self-efficacy for each group. The total of variance in Time 2 achievement associated with shared and unique variance in Time 2 self-efficacy for the Combined interventions group was 35%; for the Mathematics self-efficacy intervention group, 44%; and for the Control group, 18%. Each group shows an increase in variance in Time 2 achievement that is uniquely associated with concurrent self-efficacy, compared to the data shown in the top panel. The Mathematics self-efficacy group was the only group for which the unique variance in Time 2 achievement associated with concurrent self-efficacy (16%) was greater than the unique variance associated with earlier achievement (7%).

Figure 6.14 shows the variance in Time 3 mathematics achievement (delayed post-intervention) associated with Time 1 achievement and self-efficacy (top panel), Time 2 achievement and self-efficacy (middle panel), and Time 2 achievement and Time 3 self-efficacy (bottom panel). The top panel shows that for the Combined interventions group, 66% of the variance in Time 3 achievement was associated with Time 1 achievement, either uniquely or in combination with Time 1 self-efficacy. This was the greatest proportion of variance in achievement associated with a combination of earlier achievement and earlier or concurrent self-efficacy for any group, at any time. For the Mathematics self-efficacy intervention group, 36% of the variance in Time 3 achievement was attributable to Time 1 self-efficacy and achievement – the smallest proportion for the three groups. For the Control group, the 46% of variance in Time 3 achievement associated with Time 1 self-efficacy and achievement was the greatest proportion of variance in achievement explained for this group at any point. This panel shows the greatest unique variance attributable to earlier achievement for all groups, at any time.





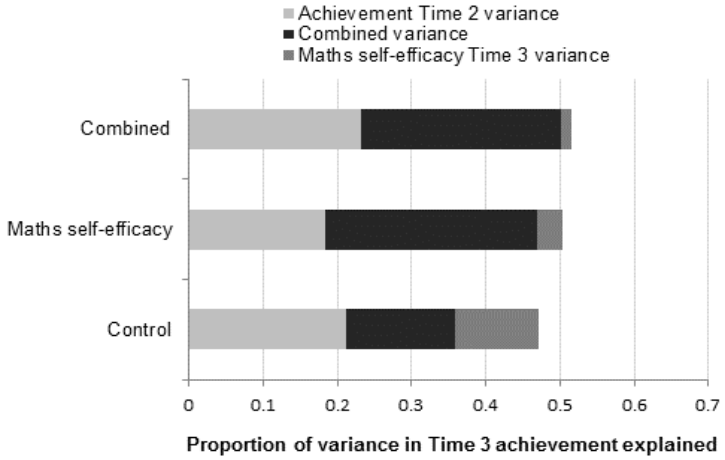


Figure 6.14. Time 3 mathematics achievement variance associated with prior achievement, and prior and concurrent self-efficacy. The top panel shows variance associated with Time 1 achievement and self-efficacy; the middle panel shows variance associated with Time 2 achievement and self-efficacy; and the bottom panel shows variance associated with Time 2 achievement and Time 3 self-efficacy. Treatment groups are: Control group; Mathematics self-efficacy intervention group (Maths self-efficacy); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (Combined).

Similar to the variance in Time 2 achievement associated with Time 1 achievement and self-efficacy (see the top panel in Figure 6.13), very little variance in Time 3 achievement was uniquely associated with Time 1 self-efficacy – only 2% for the Control group. On the other hand, the proportion of variance in Time 3 achievement associated with Time 1 achievement – both unique variance and shared variance with Time 1 self-efficacy – was greater for each group than the proportion of variance in Time 2 achievement associated with Time 1 achievement, both uniquely and shared with Time 1 self-efficacy. The picture in the middle panel changes quite noticeably for the Mathematics self-efficacy intervention group, with 53% of the total variance in Time 3 achievement for this group associated with achievement and self-efficacy, immediately post-intervention – the greatest proportion of achievement variance explained for this group in any of the combinations presented here. Variance in Time 3 achievement associated with Time 2 mathematics self-efficacy was greatest for the Mathematics self-efficacy group, where a total 41% of the variance for Time 3 achievement was associated with Time 2 self-efficacy, both uniquely and in combination with Time 2 achievement. For the Combined interventions group, the total variance in Time 3 achievement associated with Time 2 self-efficacy was 21%, and for the Control group, 16%.

The top and middle panels in Figure 6.14 show that for the Combined interventions and Control groups, Time 1 achievement and self-efficacy were associated with greater variance in Time 3 achievement than were Time 2 achievement and self-efficacy. For the Mathematics self-efficacy group, though, the reverse was evident; greater variance in Time 3 achievement was associated with Time 2 than Time 1 self-efficacy and achievement.

In the bottom panel, results for both intervention groups are comparable, and in fact, all three groups show similar total proportions of Time 3 achievement associated with Time 2 achievement and Time 3 self-efficacy. The Control group shows 11% of variance in Time 3 achievement is uniquely associated with concurrent self-efficacy, whereas unique variance in Time 3 achievement associated with Time 3 self-efficacy of less than 4% was evident for each of the two other groups. Time 2 achievement and Time 3 self-efficacy were together associated with 52% of the variance in Time 3 achievement for the Combined interventions group, with 50% of the variance in Time 3 achievement for the Mathematics self-efficacy intervention group, and with 47% of the variance in Time

3 achievement for the Control group. The total variance in Time 3 achievement associated with concurrent self-efficacy was fairly similar for each group: for the Combined interventions group, this proportion was 28%; for the Mathematics self-efficacy intervention group, 32%; and for the Control group, 26%.

Overall, the regression analyses confirmed that students' mathematics self-efficacy is associated with significant variance in achievement, highlighting the value of providing teachers with specific strategies to help strengthen students' self-efficacy. The regression also illustrates the complexity of the relationship between mathematics self-efficacy and achievement for the three groups. Most notably, (immediately) post-intervention self-efficacy was associated with a greater proportion of the variance in achievement at Times 2 and 3 for the Mathematics self-efficacy intervention group than for the two other groups. One explanation for the different pattern indicated for the Mathematics self-efficacy group is that their initial low self-efficacy levels were implicitly increased at Time 2 as a result of the self-efficacy intervention, and that this was associated with increased achievement for this group at Time 2. This groups' increase in mean achievement at Time 2 is likely in turn to have contributed to students' self-efficacy, which was then associated with increases in both achievement and explicit self-efficacy at Time 3 (see Figure 6. 1), in something of a spiral effect.

Alignment of mathematics self-efficacy and achievement

Because mathematics achievement items and mathematics self-efficacy items were both calibrated with the difficulty parameters for the achievement items, it was reasonable to compare students' scores for achievement and self-efficacy to identify how closely they aligned. Mean self-efficacy was higher than mean achievement for each treatment group at every time point. Therefore, to calculate the data represented in Figure 6.12, each student's standardised score for mathematics achievement was subtracted from their standardised self-efficacy score for each time point.

The data suggest that students' self-efficacy beliefs and achievement at the end of the school year (Time 2) were more closely aligned than at the beginning of the 2010 and 2011 years (Times 1 and 3), irrespective of treatment group. The trajectory was similar for each group over time, with time having a significant effect; F (2, 298) = 26.05, $p < 0.001$, but there was no main effect of treatment, and no

interaction effect; $F < 1$ in both cases. No significant effects of gender or year level were detected; $F < 1$ for both.

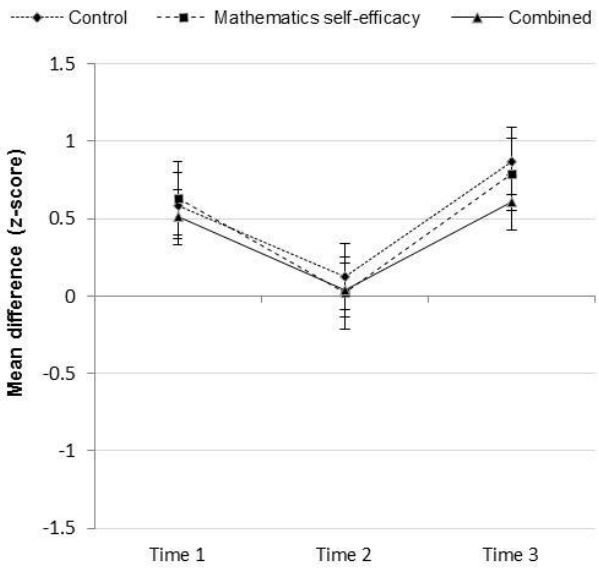


Figure 6.12. Mean differences between students' standardised scores for mathematics self-efficacy and achievement (achievement subtracted from self-efficacy), by time and treatment group: Control group; Mathematics self-efficacy intervention group; and Combined mathematics self-efficacy and theory-of-intelligence interventions group. Error bars denote standard errors of estimates.

Given that the Mathematics self-efficacy intervention group had significantly lower mean scores than the two other groups for both self-efficacy and achievement, it is interesting to note that the alignment between the two variables is very similar for all treatment groups. At the start of both school years encompassed by the study, mean mathematics self-efficacy exceeded mean achievement for the same problems.

To check whether the closer match between self-efficacy and achievement at Time 2 might be reflective of a ceiling effect caused by using the same items at Time 2 that were used at Time 1, the numbers of students with maximum scores for mathematics self-efficacy and achievement were investigated, with results presented in Table 6.4. Given that the Time 2 data showed a greater number of students were accurately judging their ability to correctly solve the 10 problems presented, a ceiling effect was suggested for this small number of students. It did not, however, account for the closer mean alignment shown in Figure 6.12.

Table 6.4: Students with maximum scores for mathematics self-efficacy

Numbers (and approximate percentages) of students from the sample (n = 152) with maximum raw scores for mathematics self-efficacy (maximum possible score = 60) and achievement (maximum possible score = 10), and those with maximum scores for both these measures, by time.

	Time 1	Time 2	Time 3
Mathematics self-efficacy	22 (*14%*)	28 (*18%*)	15 (*10%*)
Mathematics achievement	10 (*6%*)	29 (*19%*)	5 (*4%*)
Both	4 (*3%*)	10 (*6%*)	1 (*1%*)

In the overall sample, mean mathematics achievement increased from Time 1 to Time 2 by 0.70 logits and self-efficacy increased by 0.20 logits. This shows that the closer alignment at Time 2 was related to an increase in mean achievement, rather than a decrease in mean self-efficacy. Almost the reverse occurred between Times 2 and 3; mean mathematics achievement for the whole sample increased by 0.17 logits, and self-efficacy increased by 0.51 logits. Time 3, like Time 1, was near the beginning of a school year, when students' judgments of their capabilities seem to be slightly over-optimistic, unlike their end-of-year judgments.

The teacher data

Teachers completed questionnaires at Times 1 and 2, to identify their self-efficacy for teaching mathematics, and their theory-of-intelligence. Of the original 24 teachers, 21 completed questionnaires on both occasions. The teachers' total raw scores for theory-of-intelligence and their self-efficacy for teaching mathematics have been treated as ordinal data, because the sample was too small to apply a Rasch measurement model. The minimum and maximum possible scores for self-efficacy for teaching mathematics were 13 and 78, respectively, and for theory-of-intelligence, 8 and 48, respectively, assuming all questions were completed. Using teachers' total scores, appropriate statistical tests were applied, including nonparametric alternatives to compare the results by treatment group. Although teachers had not been the target of the two interventions, the possibility that they might have altered some of their beliefs as an effect of participating in the interventions was examined.

A principal components analysis with varimax rotation of the Time 1 teacher data extracted six factors with eigenvalues greater than one, and the scree plot showed

the fifth and subsequent factors bunched together and levelling off. The first four factors explained a total of 71% of the variance, and are shown in Table 6.5. With the exception of item 7, the theory-of-intelligence items loaded very strongly on Factor 1, indicating the factor measured by these items approached uni-dimensionality. (Item 7 had a loading of .90 on the fifth factor, on which four self-efficacy items had moderate loadings, making it problematic to interpret this factor in terms of theory.) Cronbach's alpha for this collection of items was also strong; α = .94.

Table 6.5: Factor loadings on teacher questionnaire items

Factor loadings based on the results of a principal components analysis for teacher items at Time 1. Items are ordered by weighting on Factor 1. Note: Factor loadings < .2 are not shown.

	Factor 1	Factor 2	Factor 3	Factor 4
Variance	36%	13%	13%	9%
Theory-of-intelligence items				
1. You have a certain amount of intelligence, and you can't really do much to change it.	.96			
2. Your intelligence is something about you that you can't change very much.	.92	.21		
6. You can learn new things, but you can't really change your basic intelligence.	.92			
3. No matter who you are, you can significantly change your intelligence level.	.91			
4. To be honest, you can't really change how intelligent you are.	.91	.20		
5. You can always substantially change how intelligent you are.	.89			
8. You can change even your basic intelligence level considerably.	.86		.21	
7. No matter how much intelligence you have, you can always change it quite a bit.				
Self-efficacy for teaching mathematics items				
20. If I really try hard in my maths teaching, I can get through to even the most difficult or unmotivated students.	.39	.76	.30	
10. I have enough training to deal with almost any learning problem in maths.	.26	.27	.20	.74
15. Teachers are not a very powerful influence on students' maths achievement when all factors are considered.	.22	.63		
13. When I really try, I can get through to most difficult students in maths.	.21	.63	.21	.60

	Factor 1	Factor 2	Factor 3	Factor 4
17. If a student masters a new maths concept quickly, this might be because I knew the necessary steps in teaching that concept.		.81		-.21
11. When a student is having difficulty with the maths work I have given them, I am usually able to adjust it to his/her level.		.25		.64
18. If a student did not remember information I gave in a previous maths lesson, I would know how to increase his/her retention in the next lesson.		.38		-.82
21. When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance in maths depends on his or her home environment.			.88	
16. When the maths marks of my students improve, it is usually because I found more effective approaches.		.20		
9. The amount a student can learn in maths is primarily related to family background.			.93	
14. A teacher is very limited in what he/she can achieve because a student's home environment has a large influence on his/her maths achievement.			.89	
19. Even a teacher with good maths teaching abilities may not reach many students.			.23	.20
12. When a student gets a better maths grade than he/she usually gets, it is usually because I found better ways of teaching that student.		.66	-.33	

Items intended to measure teachers' self-efficacy for teaching mathematics loaded mainly across Factors 2, 3, and 4. Factor 2 was interpreted as a belief that teachers influence students' learning, Factor 3 as students' learning being influenced by family background, and Factor 4 as a teacher's belief in their ability to respond to students' learning difficulties. In addition to loadings on these three factors, a number of loadings were evident for the self-efficacy items: a cross-loading on Factor 1 for item 20 (.39); loadings on Factor 5 (described above); and items 16 and 19 loading strongly on Factor 6 (.74 and .80, respectively – the only significant loadings on this factor). Despite the self-efficacy items loadings across multiple factors, Cronbach's alpha values were acceptable for the self-efficacy item collection; $\alpha = .76$.

These factors were not both the same as the two extracted from the trial self-efficacy data: the first, a belief that teachers influence students' learning, aligned with Factor 2 above; but the second, a belief that influences other than teachers are associated with students' learning, was broader than Factor 3 above. Factor 4 above was not evident in the trial data.

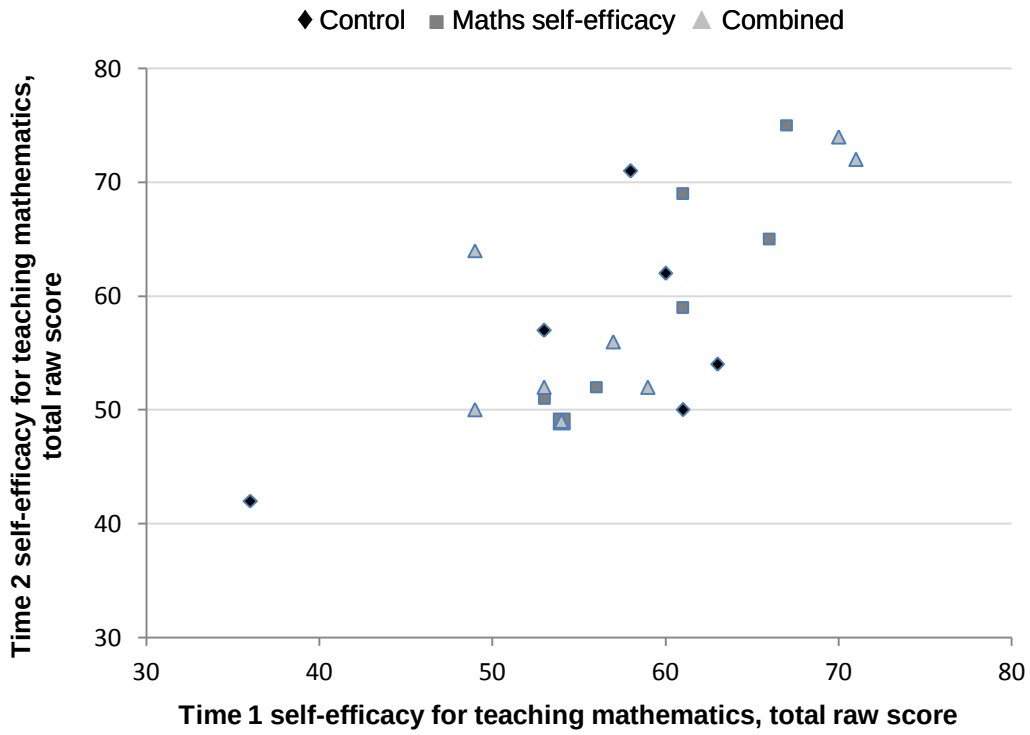


Figure 6.15. Teachers' (n = 21) total raw scores for self-efficacy for teaching mathematics at Times 1 and 2 by treatment group. Groups are: Control group (Control), Mathematics self-efficacy intervention group (Maths self-efficacy), and Combined mathematics self-efficacy and theory-of-intelligence interventions group (Combined). NB. Two teachers with scores (54, 49) were from the Maths self-efficacy and Combined groups.

Teachers' total raw scores for self-efficacy for teaching mathematics are shown in Figure 6.15. Overall, teachers' Time 1 self-efficacy scores were moderately correlated with their Time 2 scores; r = .65, p = .002. A Kruskal-Wallis test was used to compare teachers' self-efficacy for teaching mathematics in the three groups, and indicated that there were no statistically significant differences in the distribution of total scores between treatment groups.

Treatment groups' medians for teachers' theory-of-intelligence at Times 1 and 2 are shown in Table 6.6. A Kruskal-Wallis test compared the medians and distributions of teachers' theory-of-intelligence total scores, and detected no statistically significant differences between treatment groups. At the conclusion of the combined mathematics self-efficacy and theory-of-intelligence intervention, there was no evidence of significant changes in teachers' beliefs, or differences between treatment groups.

Table 6.6: Teachers' Time 1 and Time 2 theory-of-intelligence median by treatment group

Treatment group (*n*)	Time 1 theory-of-intelligence median	Time 2 theory-of-intelligence median
Control group (6)	34.0	31.5
Mathematics self-efficacy intervention group (8)	36.0	37.0
Combined interventions group (7)	27.5	33.0

Correlations between teacher measures by treatment group

Correlations between teachers' total scores for self-efficacy and theory-of-intelligence were analysed by treatment group, and the small number of significant correlations that were identified are reported here, using Spearman's correlation coefficient. For teachers in the Combined interventions group, there were significant correlations between Time 1 and Time 2 total scores for self-efficacy for teaching mathematics (r = .78), and between Time 2 self-efficacy for teaching mathematics and Time 2 theory-of-intelligence (r = .87).

Time 1 and Time 2 total scores for theory-of-intelligence were strongly correlated for teachers in each group; the Combined interventions group (r = .86); the Control group (r = .83); and the Mathematics self-efficacy intervention group (r = .97), where the correlation was especially strong, indicating these teachers' theory-of-intelligence responses were almost the same on both occasions.

Associations between teacher and student data

Is there a correlation between a teacher's theory-of-intelligence and their students' theory-of-intelligence?

Is there a correlation between a teacher's self-efficacy for teaching mathematics and their students' mathematics self-efficacy?

To test hypothesised relationships between teacher and student data, the ordinal and continuous data (respectively) were compared, with findings reported using Spearman's rank correlation coefficients in Table 6.7.

Table 6.7: Correlations between student and teacher variables

Spearman's rank correlations between teacher (n = 21) and student (n = 152) measures for Year 4 and 5 students by treatment group. Groups are: Control group (top), Mathematics self-efficacy intervention group (middle), and Combined mathematics self-efficacy and theory-of-intelligence interventions group (bottom). Note: $p < .05$ for all correlations shown; non-significant correlations are omitted.

		Teachers' self-efficacy		Teachers' theory-of-intelligence	
		Time 1	Time 2	Time 1	Time 2
Students' mathematics self-efficacy	Time 1	.30	-.45	-.32 -.53	-.40
	Time 2			-.47	-.27
	Time 3			-.40	
Students' theory-of-intelligence	Time 1	-.36 -.33	-.28		
	Time 2		-.33	.35	.34
	Time 3			-.34	
Students' mathematics achievement	Time 1			-.36	
	Time 2			-.51	-.34
	Time 3			.36	.35

Teachers' self-efficacy for teaching mathematics had fewer significant correlations with student outcomes in all groups than teachers' theory-of-intelligence. What stood out was that the correlations between teachers' and students' measures for the Combined mathematics self-efficacy and theory-of-intelligence interventions group were generally negative, with all of these that involved teachers' theory-of-intelligence negatively associated with the student measures. In particular, moderate negative correlations between the Time 1 theory-of-intelligence for teachers in this group and students' self-efficacy on all three occasions were

evident; r = -.53, -.47, and -.40, respectively, all $p < .001$. In this group, teachers' Time 1 theory-of-intelligence was a moderate, negative predictor of students' achievement towards the end of the school year at Time 2; r = -.51, $p < .001$. This indicates that teachers' having a strongly incremental theory-of-intelligence was not systematically associated with students having a high theory-of-intelligence, mathematics self-efficacy, or achievement scores.

In the Mathematics self-efficacy intervention group, there were no significant correlations involving teachers' self-efficacy. For this group, teachers' Time 1 theory-of-intelligence was a moderate positive predictor of students' theory-of-intelligence at Time 2; r = .35, p = .03, and students' Time 3 achievement; r = .36, p = .02. Teachers' Time 2 theory-of-intelligence also correlated with students' theory-of-intelligence for the same time; r = .34, p = .03, and was a moderate predictor of students' Time 3 achievement; r = .35, p = .03.

For the Control group, the picture was different again. The strongest correlations were between students' Time 1 mathematics self-efficacy measures, and the Time 2 teacher measures, both of which were negative; r = -.45, p = .01 for teachers' self-efficacy, and r = -.40, p = .01 for teachers' theory-of-intelligence.

The most significant correlations identified here between teachers' theory-of-intelligence and student outcomes were in the Combined interventions group, and were consistently negative. This did not support the hypothesised correlation between teachers' and students' theory-of-intelligence, which had been predicted to strengthen at Time 2. The lack of significant correlations between teachers' self-efficacy for teaching mathematics and their students' mathematics self-efficacy also did not support the hypothesised connection between these constructs.

The nature of theory-of-intelligence

What is the nature of students' and teachers' theory-of-intelligence?

The data in Figure 6.16 illustrate that students' standardised scores for theory-of-intelligence did not form a dichotomy, and that although there appeared to be a continuum of scores at each of Times 1 and 2, the students' scores at these time points were not significantly correlated (see Table 6.3 for details of correlations). Even though some students scored the maximum possible, Figure 6.16 illustrates that students held a wide range of beliefs about the malleability of intelligence.

Fewer students had extremely low scores than had extremely high scores, suggesting that strong entity theorists were fewer than strong incremental theorists. This was further investigated in student interviews, the findings from which are discussed in the next chapter.

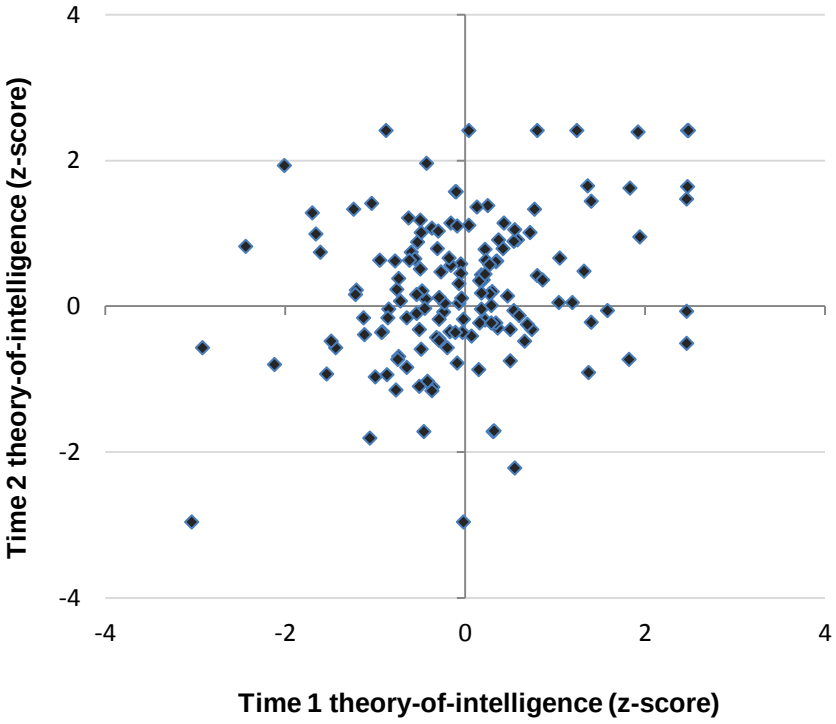


Figure 6.16. All Year 4 and 5 students' (n = 152) theory-of-intelligence standardised scores at Times 1 and 2.

Teachers' total raw scores for theory-of-intelligence are shown in Figure 6.17, and indicate that few teachers had substantially changed their beliefs when they were re-assessed at Time 2. Much less change from Time 1 to Time 2 scores was evident for teachers than was indicated for students. Their pre-intervention total scores ranged from 16 to 47 (for a teacher who responded to all items, the minimum possible score was 8, and the maximum possible score 48), and their post-intervention scores from 14 to 48. As Figure 6.17 illustrates, teachers' theory-of-intelligence scores seemed to be spread along a continuum rather than forming distinct clusters at either end of the scale, whereas if a dichotomous construct were being measured, the latter would be expected. Raw scores for Times 1 and 2 were strongly correlated, as decribed in the section, *Correlations between teacher measures by treatment group.*

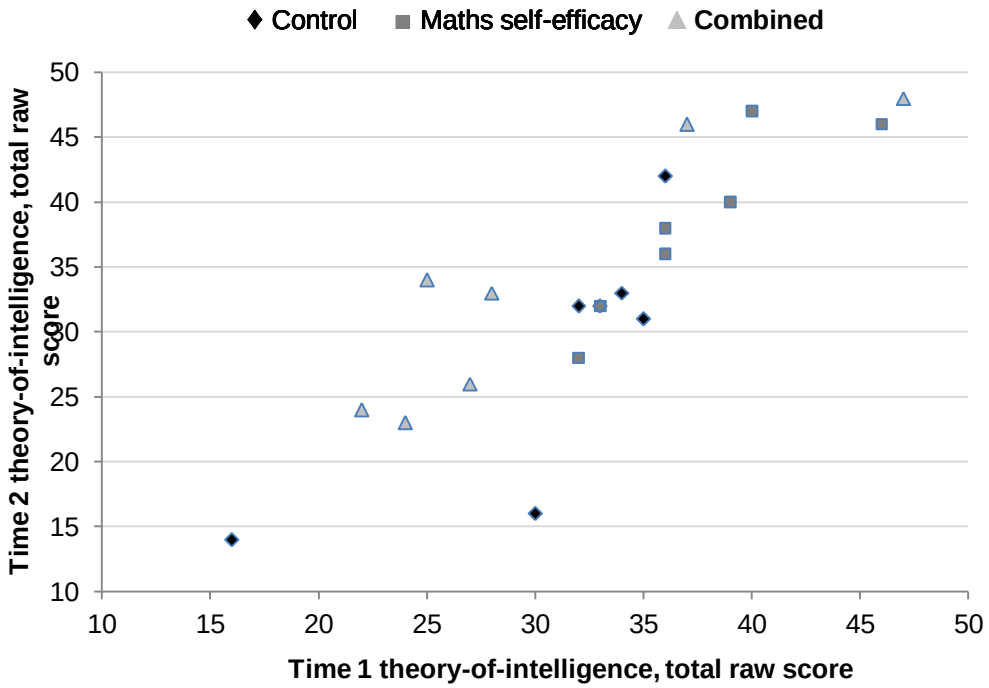


Figure 6.17. Teachers' (n = 21) theory-of-intelligence total raw scores at Time 1 and Time 2. Groups are Control group, Mathematics self-efficacy intervention group, and Combined mathematics self-efficacy and theory-of-intelligence interventions group. Total scores for two teachers from the Mathematics self-efficacy intervention group are represented at (33, 32).

Chapter summary

This analysis of the quantitative data indicated that the study's hypotheses relating to theory-of-intelligence were generally not supported. No significant effects of an intervention that focussed on developing students' incremental theory-of-intelligence were evident for students in the Combined interventions group, whose mean theory-of-intelligence was not significantly higher than those of the two other groups. The hypothesis that Year 4 students would indicate a stronger incremental theory-of-intelligence than Year 5 students was not convincingly supported, with a tendency towards this shown only in the Mathematics self-efficacy intervention group. Across the three treatment groups, there was no consistent evidence to support the hypothesised gender difference in theory-of-intelligence. Neither was there evidence that students' theory-of-intelligence scores represented a dichotomy. The continuum of Time 1 scores was not significantly correlated with the continuum of Time 2 scores, suggesting the instrument might not have been a valid and reliable measure of students' beliefs about the malleability of intelligence. Teachers' theory-of-intelligence beliefs, on the other hand, appeared to form a continuum, and strong correlations between their Time 1 and Time 2 scores were

evident. Almost no students had extremely low theory-of-intelligence scores that would be indicative of a strong entity belief; this was further investigated in the student interviews, reported in the following chapter. There were few significant correlations between students' mean theory-of-intelligence and mathematics self-efficacy or achievement.

In contrast to the theory-of-intelligence data, the mathematics self-efficacy data supported most of the related hypotheses involving mathematics self-efficacy and achievement. The most distinct increases in mean mathematics self-efficacy and achievement were shown in the Mathematics self-efficacy intervention group, suggesting a positive effect for these students of the mathematics self-efficacy intervention. Within treatment groups, no significant effects of gender were indicated for self-efficacy. The hypothesis that Year 4 students would show stronger mathematics self-efficacy than Year 5 students was not supported by the data. On the contrary, in the Combined interventions group, Year 5 students' mathematics self-efficacy was significantly higher than that of Year 4 students, on all three occasions.

There was evidence to support the hypothesised correlation between mathematics self-efficacy and achievement. A regression anaylsis confirmed that students' self-efficacy is associated with significant variance in mathematics achievement. As anticipated, Year 5 students had greater mean achievement scores than Year 4 students.

The hypothesised positive associations between teachers' beliefs and student measures were not supported by the data. In the Combined interventions group, significant moderate negative correlations were identified between teachers' theory-of-intelligence and students' mathematics self-efficacy and achievement. A significant moderate correlation was evident between teachers' self-efficacy for teaching mathematics at Times 1 and 2. Their theory-of-intelligence scores at on both occasions were strongly correlated, consistent with previous findings (Ball, 1996; Hargreaves & Shirley, 2009; Lortie, 1975) that teachers' beliefs are difficult to change.

CHAPTER 7
Students and Teachers Talk about Mathematics Self-Efficacy and Intelligence

The interviewees

Students and teachers were interviewed on two occasions to gain an understanding of their ideas about mathematics self-efficacy and theory-of-intelligence, and to determine the degree to which this information supported the questionnaire data. The sample of students who were interviewed was designed to provide opportunities for contrasting those with low and high levels of mathematics self-efficacy and theory-of-intelligence, as is shown by the breakdown in Table 7.1. Unlike the between-treatment comparisons made with the quantitative data, the comparisons drawn in this chapter are more often between, for example, the groups of students with low self-efficacy and high self-efficacy scores in their Time 1 questionnaires, irrespective of their treatment groups.

Table 7.1: Student interviewees at Times 1 and 2 by mathematics self-efficacy and theory-of-intelligence levels

Student interviewees were identified from students' Time 1 questionnaire results. To be categorised as "low mathematics self-efficacy" (or theory-of-intelligence), a student had a logit score in the lowest one-third of scores for their year level, and to be categorised as "high mathematics self-efficacy" (or theory-of-intelligence), a student's score was in the highest one-third.

	Low theory-of-intelligence	High theory-of-intelligence
Low maths self-efficacy	11	11
High maths self-efficacy	12	12

Although the original intention had been to select students for the first interview on the basis of having extreme scores in their Time 1 questionnaire data, their total raw scores for mathematics self-efficacy and theory-of-intelligence were not spread as widely as had been anticipated. It was straightforward to identify students with high scores in both, but combinations involving very low scores were not so numerous. A cluster analysis identified two clusters located in the top and bottom thirds of the data, one with mean logits scores of .51 for mathematics self-efficacy and 1.48 for theory-of-intelligence, and the other with mean scores of -.51 and -1.13, respectively. The selection criteria were modified, therefore, to include a balance of students whose total scores were amongst the lowest – and highest – one-third of all scores for mathematics self-efficacy and theory-of-intelligence.

The sample was also designed to have similar representation from Years 4 and 5, and from each treatment group, as is shown in Table 7.2. Boys and girls were equally represented in the Year 4 students. There were few Year 5 boys with extremely low or high scores in the Combined interventions group, and when two boys were absent for their first interviews, substitutes – who had similar scores and were also available for interviews – could not be identified. The result was that Year 5 boys had the smallest total number of interviewees at both interviews.

Table 7.2: Student interviewees by year level, gender, and treatment group

Student interviewees at Times 1 (and Time 2, shown in parentheses) by year level, gender, and treatment group. Note: "Combined interventions group" is the Combined mathematics self-efficacy and theory-of-intelligence interventions group.

Treatment group	Year 4		Year 5		Totals	
	Boys	Girls	Boys	Girls	Boys	Girls
Control group	3 (3)	4 (4)	3 (3)	4 (3)	6 (6)	8 (7)
Mathematics self-efficacy intervention group	4 (2)	4 (4)	4 (3)	4 (4)	8 (5)	8 (8)
Combined interventions group	5 (5)	4 (4)	2 (1)	5 (5)	7 (6)	9 (9)
Totals	12 (10)	12 (12)	9 (7)	13 (12)	21 (17)	25 (24)

Fifteen teachers from the two intervention groups were interviewed at Time 1 and again at Time 2. Eight teachers were from the Mathematics self-efficacy intervention group (identified later as teachers A to H), and seven from the Combined mathematics self-efficacy and theory-of-intelligence interventions group (teachers J to P).

Describing students' mathematics self-efficacy beliefs

> Researcher: And why did you think that you could answer most of the questions I showed you?
>
> Student: Well, that's because most of them were easy, and I'm very smart for my age. (Year 5 girl, high self-efficacy score)

Students like this one, who were selected for interview because they showed high mathematics self-efficacy (n = 24), were generally able to explain why they made these judgments in relation to the mathematics problems they were shown, as were

students who were interviewed due to their reported low self-efficacy (*n* = 22). The reasons students gave for their self-efficacy at both interviews are summarised in Table 7.3.

Table 7.3: Students' reasons for their mathematics self-efficacy judgments

Summary of students' Time 1 (and Time 2, shown in parentheses) interview responses when asked why their mathematics self-efficacy seemed to be low or high, according to their questionnaire responses, by self-efficacy levels in Time 1 questionnaire. A number of students' responses fell into more than one category. At Time 2, 20 students with low and 21 with high self-efficacy were re-interviewed.

Reasons given by students for their self-efficacy level	Low mathematics self-efficacy *n* = 22	High mathematics self-efficacy *n* = 24
Difficulty of tasks	9 (3)	2 (1)
Easiness of tasks	1 (5)	10 (12)
Mathematics knowledge, ability	6 (8)	6 (12)
Confidence to attempt problems	4 (1)	3 (1)
Familiarity of problems	0 (1)	4 (0)
Other	2 (0)	1 (0)
Don't know	1 (1)	1 (1)

Students were asked to confirm my interpretation of their questionnaire responses as indicating that they had thought they could solve either very few, most, or all of the problems they were shown. They consistently agreed that their mathematics self-efficacy level had been accurately interpreted. At Time 1, students' explanations that expressed their perceptions of the easiness or difficulty of the mathematics problems were largely aligned with their high or low mathematics self-efficacy, respectively. The most frequent explanation from students with low mathematics self-efficacy (*n* = 9) was that the problems were difficult for them. For example, one girl explained that "Some of them were very hard, quite big numbers and quite complicated" (Year 5 girl, low self-efficacy score). In contrast, 10 students whose questionnaire responses indicated high mathematics self-efficacy (*n* = 10) described the problems as easy. A typical explanation was "Coz I knew most of them and they were so easy that I could figure them out quickly in my mind, with no hands" (Year 4 girl, high self-efficacy score). Students' perceptions of task difficulty were generally – and not surprisingly – associated with their mathematics self-efficacy levels.

The 12 students' Time 1 comments that were classified as relating to their mathematics knowledge or ability included expressions of negative perceptions by four students with low self-efficacy, including: "Because I'm not good at maths" (Year 5 girl, low self-efficacy score). Seven other students expressed a belief that they had the mathematics knowledge needed to solve the problems, such as the student who explained: "Coz I know how to work out the questions" (Year 4 boy, high self-efficacy score). One of these students claimed that he found it helpful to know about his stage on the Number Framework, information which was shared by his teacher with each student. He said that "I know what stage on the ladder I am and that sort of helps. On the ladder there's a stage … and since I'm up to six I'm up to the times table and division stuff" (Year 5 boy, high self-efficacy score). In contrast, the remaining student who made a comment that was included in this category was unsure of his ability in mathematics: "I'm not sure if I'm really good at maths or a bit good at maths" (Year 4 boy, low self-efficacy score).

Two students' responses in the same category also suggested a link between a student's mathematics self-efficacy and their perception of their ranking within the class for mathematics. One girl explained that her self-efficacy score had been low "Because I was in the low group then, I wasn't really good at maths, I'm not quite so good at it" (Year 4 girl, low self-efficacy score). On the other hand, another said that the reason her self-efficacy score had been high was "Coz I'm higher, and a lot good at maths, I'm better than other kids my age" (Year 5 girl, high self-efficacy score). These two students seemed to have a clear picture in their own minds of their mathematics skills in relation to those of their classmates, which may have been associated with their mathematics self-efficacy levels.

Confidence and a willingness to attempt mathematics problems were reasons given by seven students for their self-efficacy levels. Three students mentioned confidence in their explanations, and four described a positive attitude towards trying to solve what might not appear to be easy questions. One girl, for example, explained that "If I just try them, I might realise I can actually do them, even though I don't know the answer" (Year 5 girl, high self-efficacy score). Like this student's comment, some of these responses included suggestions of doubt that the students would successfully solve the problems, which was perhaps symptomatic of the students' mathematics self-efficacy levels being slightly in advance of their ability to actually solve some of the problems with which they were presented. Alternatively, students might have responded this way because they had not yet

attempted to solve the problems, so were unwilling to express certainty that they could.

None of the four students listed in Table 7.3 as indicating they were familiar with the problems they were shown, was from a class that had done the achievement test prior to the first questionnaire, although students had completed the test by the time they were interviewed. Their comments that they thought the problems they were shown were easy because they had already seen them, might have referred to having previously encountered the same problem types rather than those specific problems.

Three students expressed other reasons for their reported mathematics self-efficacy. Two of these related to students needing more time than they were given to think about their ability to solve the problems presented, as described here:

> Student: It's just that I take a lot of time thinking, coz it's easy to get things wrong if I don't really think about it.
>
> Researcher: So are you telling me then, that because I only showed them to you for a few seconds, you didn't have enough time to tell if you could solve them?
>
> Student: Yeah. I didn't actually see if I could answer them … to actually think of the strategies. (Year 4 girl, low self-efficacy score)

The third student explained that "There were no wrong answers, it was our opinion", to account for his self-efficacy responses (Year 5 boy, high self-efficacy score).

Table 7.3 also includes students' reasons for their mathematics self-efficacy responses in the Time 2 questionnaire, explained in their second interviews. Compared to students' Time 1 responses, fewer students with low mathematics self-efficacy talked about the mathematics problems being difficult (3 at Time 2 compared to 9 at Time 1), and more students commented that the problems were easy (17 compared to 11). This increase in students' perceptions that problems were easy probably reflects the increase in mean achievement at Time 2 that was evident for students in all groups (see Figure 6.1), coupled with the correlation identified between achievement and mathematics self-efficacy (see Table 6.6).

Twenty students' explanations of their mathematics self-efficacy included a reference to their perceptions of their mathematics knowledge or ability, and 17 of these were positively expressed, compared to seven in the first interviews.

For instance, students' Time 2 explanations for their self-efficacy responses in their second questionnaire reflected their awareness of increases in their mathematics knowledge since Time 1: "Coz probably I know lots more addition and subtraction, and if it was division and multiplication, I already know my tables, so that would make it easier" (Year 5 boy, high self-efficacy score). Another responded that "just the other day we learnt how to do a method about making the littlest one a tidy number, and then I didn't really know it, so I think that might have been trickier" (Year 4 girl, low self-efficacy score). At Time 1, six students in each of the low and high mathematics self-efficacy score groups expressed reasons that fell into the mathematics knowledge or ability category. At Time 2, the number of students who made this type of response increased more for those with high mathematics self-efficacy scores at Time 1 (n = 12), than for those with low scores (n = 8).

At the Time 2 interviews, a question about changes in students' mathematics self-efficacy levels was included. When nine students who had reported low mathematics self-efficacy at Time 1 were asked about an increase in mathematics self-efficacy indicated by their Time 2 questionnaire data, six students explained that their increases were associated with having learnt more mathematics since Time 1. This student explained that she thought her mathematics self-efficacy had changed from very low to very high because "In between term two the teacher got a bit harder at maths, so I thought I'd learnt more, so I could get them much easier" (Year 4 girl, low self-efficacy score).

Four student interviewees had reported high Time 1 self-efficacy followed by a decrease in self-efficacy at Time 2, and three either responded that they did not know why they reported being less sure of their ability to solve the problems, or gave what were very uncertain answers, judging by their intonation. The fourth student, whose Time 2 mathematics self-efficacy score was lower than Time 1, explained this was "Maybe coz I'm struggling in my basic facts lately, coz I'm not getting higher than at least thirty [out of fifty questions in a regular basic facts test], so I need to improve" (Year 5 boy, high mathematics self-efficacy score). The quantitative data for these students showed that for the three Year 5 students, their mathematics self-efficacy scores were all higher than their achievement at Time 1, and at Time 2, their self-efficacy and achievement scores were almost aligned, similar to the overall trend shown in Figure 6.9. In contrast, for the Year 4 student, the gap between his two scores had increased at Time 2, with mathematics self-efficacy 2.72 logits lower than achievement due to a big drop in self-efficacy since

Time 1. This otherwise-confident student – the only Year 4 student in this group – somewhat hesitantly offered this explanation for his drop in self-efficacy: “Coz I didn’t really know the answer back then?” (Year 4 boy, low self-efficacy score). The reasons underlying the decreases in reported mathematics self-efficacy may vary for these students, but it seems possible that the Year 4 boy did not understand what was being asked of him in the questionnaire. The Year 5 students, on the other hand, may have begun the year with levels of self-efficacy that exceeded their actual achievement, and during the year their beliefs in their mathematics ability may have become more closely aligned with their achievement as a consequence of a growing awareness of assessment information.

To summarise the students’ perspective, their explanations of their mathematics self-efficacy were consistent with their questionnaire responses. In the Time 2 interviews, towards the end of the school year, a number of students’ comments reflected an awareness of the progress they had made in their mathematics learning since the Time 1 data were collected, making them more sure of their ability to solve the problems they were shown for the second time, with more students than at Time 1 reporting that they found the problems easy. This agreed with the correlation between mathematics self-efficacy and achievement, and the increase in the latter, evident in the quantitative data. Some students’ apparent awareness of the progress they had made in their mathematics learning over the 7 months between interviews may also have contributed to the closer alignment of their mathematics self-efficacy and achievement indicated in the quantitative analysis (see Figure 6.9).

Before the intervention meetings got underway, teachers were asked about the factors they thought contributed to students’ self-beliefs about their mathematics abilities, and which of these factors they could influence. The factor mentioned most frequently by teachers (n = 12) was the influence of parents or family, which teachers said they tried to influence through various forms of parent education or home-school partnership programmes. The influence of peers, identified as a factor by nine teachers, was a consideration when they established ground-rules with students for their classroom culture. Students’ past achievement was mentioned by nine teachers as a factor that could contribute to students’ mathematics self-efficacy, and several talked about the importance of ensuring students were successful in mathematics. Another factor that teachers thought influenced students’ mathematics self-efficacy was students knowing which mathematics

group they are in (n = 3). What was perhaps most surprising though, was that just five teachers suggested that a student's school or teacher were factors in shaping their mathematics self-efficacy. Perhaps this was because the remaining teachers thought this was self-evident. No teacher explicitly mentioned a student's emotions as a factor that might influence their mathematics self-efficacy, although these were perhaps alluded to when they talked about the effect of grouping, and developmental considerations were not raised.

Participants' experiences of the mathematics self-efficacy intervention

> I was always confident that I could solve things, and I just had to work it out, coz if I didn't believe that I could do it, then it would've been a lot harder, coz it's all about attitude. (Year 5 boy, high self-efficacy score)

> It's like anything – if you think you can do it, you can do it. It's not just maths, it's everything. (Mathematics self-efficacy intervention group teacher A)

The mathematics self-efficacy intervention aimed to give teachers strategies for developing their students' mathematics self-efficacy – to build a "can do" attitude to mathematics, like those expressed by the student and teacher above.

Using similar peers as models

As one strategy to help build students' belief in their mathematics abilities, intervention group teachers were encouraged to use similar peers as models. During the intervention meetings teachers discussed situations in which they already did this, and what might be potential difficulties for increasing peer modelling, particularly involving less able students. Teachers' comments described here tended to focus on the involvement of students as models, while students talked about the effects of observing their peers modelling or explaining their mathematical thinking.

Six teachers set themselves goals related to including or increasing peer modelling during mathematics lessons, and the comments they later made about this tended to include increased participation and engagement, particularly from students working at lower levels. One teacher reflected that she had initially had to spend time teaching appropriate language to students of lower ability, who had until then had fewer opportunities to share their thinking with the class than the more able

mathematicians. Her observation of the effect of the similar peer modelling strategy was that “This particular group of children who do find maths a challenge have just loved being the ‘teacher’ and sharing their strategies. It’s definitely boosted their confidence” (Mathematics self-efficacy intervention group teacher B). Another teacher said that “Students who are usually passive are more engaged – it’s also easier for me to be sure they have picked up a particular strategy” (Combined interventions group teacher). Including the students working at lower levels in peer modelling had had a very positive effect in another class, according to a teacher who reported that “People like [a Year 4 girl] has made huge improvements just because she has better self-efficacy now” and that “it’s the Year 4 girls … they know now and they ask, can they stand up at the end of maths and share something they’ve learnt, or can they teach the class something about fractions?” (Combined interventions group teacher K). These teachers’ comments reflected the positive effects on students of taking the role of peer model. However, not all students liked being included in peer modelling. One boy described the strategy he used to avoid being asked to explain his mathematics thinking to the class:

> Student: I don’t want to say it. I don’t put my hand up, and I always look like I’m paying attention so he doesn’t pick me, and I don’t want to answer the questions.
>
> Researcher: So you don’t like talking in front of the whole class?
>
> Student: No. I like doing it with twos, we ask each other. (Year 5 boy, Control group)

When students were asked about their experiences of peer modelling from the audience’s point of view, several said that hearing an explanation from a student who was more advanced in mathematics than they were was beneficial to their learning. One student said that she preferred to listen to an explanation from “Probably someone higher, coz then they can tell me things that I don’t really know” (Year 5 girl, Mathematics self-efficacy intervention group). When the same student was then asked about the effect of peer modelling from a student who was at a similar mathematics level to her, she responded: “Well, if I did a bit bad at it, I usually get it, if they explain it well” (Year 5 girl, Mathematics self-efficacy intervention group).

Others commented on the positive effect of having another student at the same mathematics level explain how they solved a problem. One student said that this

would make him feel “Really confident, because if someone at my level of maths helps me to figure out the question, it’ll be easier” (Year 4 boy, Combined interventions group). Another student who saw benefits in similar peers modelling how they solved a problem commented that “It’s good, coz then I get to see their opinion and how they worked it out” (Year 5 girl, Mathematics self-efficacy intervention group).

Students who were less able in mathematics were also chosen to explain their thinking, according to one student, “Because some might not be that bright, but he chooses them too because they’ve done the right things” (Year 4 girl, low mathematics self-efficacy). Students did not specifically talk about the effects on their own learning of less able students being peer models, but seemed to value everyone being included, “Because we’re all in different groups and we learn different things” (Year 5 girl, high mathematics self-efficacy score).

One student, though, was sensitive to students who were similar to her in mathematics level but younger than her, being invited by the teacher to explain strategies that she had been unable to apply. She said: “It feels OK, but if they get it right and then I didn’t know, it makes me feel a bit weird coz some of them are younger than me” (Year 4 girl, Mathematics self-efficacy intervention group). So although students might be similar in one regard, a student’s perception of dissimilarities can also influence their experience of a “similar peer” modelling strategy.

Students gave a mixture of reasons they thought their teachers might use peer modelling, ranging from behaviour management to being inclusive to monitoring students’ learning. A summary of their ideas at Time 2 is shown in Table 7.4. The highest frequency of comments for each group was for those coded as being related to inclusive learning, with students in the Combined interventions group mentioning this the most often (n = 12). Students seemed to be aware that their classes comprised a range of ability levels, and many appeared to appreciate that there might be social as well as academic reasons for including all students in sharing their mathematics thinking with the rest of the group or the class. One girl explained that her teacher used peer modelling “So she can give the people who aren’t so good at it a chance to say what they think the answer is” (Year 5 girl, Mathematics self-efficacy intervention group). Similarly, a boy thought that “Otherwise it’d be unfair, and the ones that aren’t smartest won’t learn much, just being told what it is … it just helps, so that not only the people who are good at

maths get better at maths" (Year 4 boy, Mathematics self-efficacy intervention group). Students seemed to value their teachers including students of various abilities in sharing their solutions and ideas during mathematics lessons.

Table 7.4: Students' reasons for teachers' use of peer modelling

Summary of students' reasons for teachers' use of peer modelling during whole-class components of mathematics lessons, at Time 2 interviews, by treatment group. Several students' responses fell into more than one category. Note: "Combined interventions group" is the Combined mathematics self-efficacy and theory-of-intelligence interventions group.

Reasons suggested by students	Control group *n* = 13	Maths self-efficacy group *n* = 13	Combined interventions group *n* = 15
Inclusive learning	7	10	12
Monitoring students' learning	3	2	4
Behaviour management	3	1	0
Other	3	0	1
Don't know	1	1	0

Students also suggested there were circumstances in which teachers needed to deliberately call on the more able mathematicians in the class. One such circumstance was "When she asks someone that can't figure it out, she asks someone who's smarter" (Year 4 boy, Combined interventions group). Another was "when they're the questions from that person's group and only the ultra-smart people put up their hands" (Year 5 boy, Combined interventions group).

Sometimes teachers asked students for their ideas as a behaviour management strategy, according to four students. One girl explained that "Sometimes she picks on them coz they've either been talking on the mat, or just to see if they really know what they're doing" (Year 5 girl, Control group). Another student may have been speaking from experience when, after a considerable pause, he said his teacher sometimes directs a question to a particular student "To, um, to wake them up" (Year 5 boy, Mathematics self-efficacy intervention group).

Peer modelling was generally appreciated by students as supporting their learning, as well as their sense of fairness and inclusion. Students appeared to find it more helpful to have a similar peer, or one who was more advanced than them, to model their solutions to a mathematics problem, rather than a student who was at a lower mathematics level than they were. They seemed to value having a classroom

culture, though, in which all students were expected to share their thinking. Teachers' comments indicated that some students who had been struggling with mathematics had become more engaged due to the increased use of peer modelling.

Increasing the use of descriptive teacher-student feedback

Another focus for teachers in the mathematics self-efficacy intervention was to use more descriptive teacher-student feedback and less evaluative feedback, using Tunstall and Gipps' (1996a) typology (see Figure 4.1) as a guide. Five teachers' answers to interview questions about how their practice had changed as a result of this intervention highlighted using teacher-student feedback for teaching rather than for praising alone, and using descriptive feedback more often, making responses such as: "My feedback is more specific, that's probably been the thing I've worked on the most … it's teaching more than just praising, even though they need both. Praise then teach" (Mathematics self-efficacy intervention group teacher C). Another explained that she would "Try and make sure that the feedback I give them is in relation to the work that we're doing, and try and draw their attention to the skills that they are developing" (Combined interventions group teacher M). Finally, one teacher described the change he had made in terms of Tunstall and Gipps' (1996a) categories of feedback, saying that "It's definitely gone more towards the descriptive feedback than the evaluative ... the approving and disapproving part of evaluative are very easy to do, and that's really surface level sort of stuff" (Mathematics self-efficacy intervention group teacher E). Although he was aware of the purposeful nature of the feedback he was aiming to give students, one of the practical challenges was to do this with every student. As he said, "my small groups tend to be eight or nine, but to touch base with each kid and try and give descriptive feedback is rough" (Mathematics self-efficacy intervention group teacher E). Issues like this were discussed at a later intervention group meeting, with suggestions made by other teachers for ways to manage giving descriptive feedback about their mathematics learning, for instance, to initially plan to give descriptive feedback to each student once over the course of a week until this becomes part of a teacher's everyday practice.

At Time 2, interview responses from teachers in the Mathematics self-efficacy intervention group suggested they had made greater changes to their feedback practices than teachers in the Combined interventions group, although the reason

for this is unclear. For several teachers in the former group, applying this to mathematics lessons was something they were still developing. One teacher, for example, reported that “I tend to use success criteria more in my topic work, I always use learning intentions throughout, but I’ve started using a lot more success criteria in maths” (Mathematics self-efficacy intervention group teacher C). As a colleague explained, “This is just something that we’ve started doing, so we’re at the beginning of a process” (Mathematics self-efficacy intervention group teacher D).

The focus on feedback prompted several teachers to raise their expectations of students’ learning. This teacher described the effect of changes she had made to her interactions with students:

> I think it’s galvanised a few things for me, in that one of the particular strategies I applied I did quite rigorously, and quite, I guess you could say, ruthlessly. If you were in the room, and there were the tears, we just kept working through the problem until the smiles came because they’d done it, and that was highly successful in building capacity to think, I can do, rather than seeing the tears and thinking, back up the bus, and we’ll stop there. So, working through that, “I can’t” and … structuring the questions but keeping the pressure on till you get to a place where, “I can, I can”. … It really was effective, and I think it was effective for those watching as well as those doing. … They don’t melt so much, and the kids are prepared to keep at it a bit more. (Mathematics self-efficacy intervention group teacher B)

Rather than pulling back when her students signalled that something was difficult, this teacher had made a conscious decision to press on, and found that helping students to work through their difficulty had been empowering for them. As she said, “Being kind, but putting the pressure on as well” (Mathematics self-efficacy intervention group teacher B) was beneficial to her students’ learning. Another teacher commented that he also felt he was “a bit more challenging now” and that his recent expectation that students need to demonstrate they understood what they have been working on before leaving him to work independently, was “quite uncomfortable for them, and maybe that’s part of being honest, that you are going to feel uncomfortable” (Mathematics self-efficacy intervention group teacher D). Some teachers had begun to make changes to the ways in which they gave students feedback about their learning in mathematics, and for some this also included changing their ways of interacting with students, and increasing their expectations for students’ learning and engagement during mathematics. While this involved changes for teachers, there were also adjustments to be made by their students.Students were also asked about teacher-student feedback during mathematics, including the feedback that they found the most

helpful for their learning. Knowing their next learning step was highlighted by three students as supporting their learning, as this student explained: “The most helpful is when he says this is your next step because it’s like expanding your learning” (Year 5 boy, Combined interventions group). In addition to next learning steps, four students highlighted the value they perceived in their teachers explaining exactly why their strategies did not solve the problem. This student commented that this helped her learning “because you know what you can actually improve on and you know that you can improve on something and you know what you need to learn next” (Year 5 girl, Combined interventions group).

When asked directly if their teachers regularly told them about their next learning steps, most students confirmed that their teachers did this either regularly or sometimes. This student’s teacher shared learning intentions and success criteria with students:

> Student: Yeah, yeah, she does that in every subject.
>
> Researcher: And does she tell you how you’re going to get there, what you need to do to get there?
>
> Student: I think sometimes she goes, like, this is how you’ll know when you got there, and all that. (Year 4 girl, Combined interventions group)

One student explained that his teacher had told him that his next learning step was to learn the six and nine times tables so that he would have instant recall of them, “Coz I use different strategies to work out the answers, instead of just telling him the answers” (Year 5 boy, Mathematics self-efficacy intervention group).

When describing the feedback their teachers gave them, though, few students said that their teachers gave them descriptive feedback about exactly what it was they had done well, or not so well. This response was fairly representative of the students’ perspectives:

> Student: He would probably say that we would have to try a bit harder sometimes, but when we get it nailed he says you’re doing a great job, you could probably go and work off the maths wall or go and work on the maths box games.
>
> Researcher: And when you’ve done it well, does he tell you exactly what you’ve done well?
>
> Student: No, he just says we’ve done it well. (Year 4 girl, Mathematics self-efficacy intervention group)

Although teachers in the intervention groups tended to report that they were using more descriptive teacher-student feedback during mathematics, this was not so evident in students' interview responses. This might be related to the challenge one teacher mentioned of giving detailed feedback to individual students in terms of the learning intentions and next learning steps. Several students said that having their next learning steps described to them by their teachers, along with how students would know they have achieved these steps, was helpful for their learning.

Providing students with coping strategies

Another strategy that was presented in the intervention meetings was to model coping strategies for students so that they knew appropriate ways to respond when learning was difficult for them. One teacher described the effect this had had on her students, saying that "if you've got a group on the floor and they're using their scrapbooks, they'll just chuckle now, and say, oh, I know that's wrong, I should've done such-and-such, they're very relaxed about making mistakes and that's about me role-playing" (Combined interventions group teacher K). Mathematics intervention group teacher B, who was quoted earlier describing how she had insisted that a student work through their difficulties until they achieved success, also helped this student cope by maintaining a focus on the mathematics problem and largely ignoring the student's emotional reaction. Several teachers described students becoming more accepting that learning is often challenging, and that mistakes are a valuable part of the learning process. An awareness that teachers needed to carefully judge the degree of challenge for individual students was voiced by one teacher who said that her students "understand that I wouldn't ask them to do something they couldn't do, by applying themselves" (Combined interventions teacher P). As another teacher in the same intervention group said, when talking about the start of the next school year, "I will most definitely be establishing the concept of you <u>can</u> do it, and learning is a process, learning is hard the first time, but don't be discouraged by that, keep working on it, and you'll get there" (Combined interventions group teacher M).

Effects of ability-grouping on students' mathematics self-efficacy

During the interviews, the effects of ability grouping for mathematics (or its proxy in the Numeracy Development Projects, strategy grouping) arose as a possible influence on students' self-efficacy beliefs. For example, a teacher talked about her belief that grouping students for instruction according to the stage on the Number

Framework at which they were working, recommended in the Numeracy Development Projects, influenced self-efficacy. She said: “I think it has a huge effect, I really do, in the way that the two top groups, I’m sure they make better progress and achieve more because they think they can do it”. In contrast, she commented that “The ones in the bottom group, even though they’re happy because they’re doing stuff they can manage … I’m sure their self-efficacy is harmed” (Combined interventions group teacher N). When the question of how strategy-grouping might affect students’ mathematics self-efficacy was subsequently discussed at intervention group meetings, most teachers seemed to think that students in the lowest strategy group would be negatively influenced by this practice because “Labelling often scars students, they believe they are dumb if they are in the lowest group” (Mathematics self-efficacy intervention group teacher F). Another teacher in this group suggested that for a student to be aware that “I’m always a Triangle” (assuming the Triangles is the lowest group A) would negatively affect their self-efficacy. On the other hand, students in the “highest group were happy to be there and feeling most confident” (Mathematics self-efficacy intervention group teacher E). Although ability-based grouping might have an effect on students’ mathematics self-efficacy, what is being described in most of these comments is more consistent with students’ broader self-concept than their self-efficacy.

Students’ comments confirmed that they felt very positive about being in what they thought was the highest group. A girl who said she likes her group “coz I think it’s the highest group” (Year 5 girl, high mathematics self-efficacy score) was fairly typical. The student’s comment that by being in the highest group “I feel way more encouraged, because I feel like I’m doing really well, and that’s going to encourage me to do more” (Year 5 boy, high mathematics self-efficacy score) supports the teacher’s suggestion above that the learning of those students who knew they were achieving well, would probably continue to thrive. The single student who said she was in the group in her class that was given the easiest mathematics work gave no answer when asked about how she felt about this. That grouping and mathematics self-efficacy levels are likely to be associated for some students was also supported by the students who were reported earlier as commenting about the group they were in when explaining their self-efficacy levels.

A small number of teachers were exploring alternative strategies to structure teaching mathematics in ways designed to avoid particular students’ self-efficacy

being negatively affected by an ability-grouping strategy. Students in one class described being taught in fluid groups that targeted students' learning needs in particular number domains, such as addition and subtraction, multiplication and division, and place value. One of these students said that being included in the place value group made her feel "More confident, because that way I know that the teacher's spotted my difficulties and, so she will be able to help me" (Year 5 girl, high mathematics self-efficacy score). It was unclear, though, whether some students might be included in all of these groups, which might still negatively influence their self-efficacy. In another class, peer teaching was included in the mathematics programme: "Well, right now, we're not going in groups, but we're going for people who aren't sure with people who are sure how to do it" (Year 4 girl, low mathematics self-efficacy score).

Teachers' second interviews were conducted after they had participated in two intervention group meetings that focussed on mathematics self-efficacy, where a student's self-efficacy was described as being influenced by: prior achievement; observations of others' experiences; persuasion from others; and physiological and emotional responses. When teachers were asked to name the factors that they believed contributed to students' mathematics self-efficacy, four teachers included a student's prior achievement in mathematics. None mentioned the effect of observing similar peers as models. One teacher included strategies for coping with difficulty, and another talked about a particular student's negative emotional response to basic facts testing – both of which related to physiological and emotional responses. Much more frequently, teachers highlighted the contributing effects of: parents' comments to students (n = 7); peer support and encouragement (n = 6); and teacher-student feedback (n = 5), all of which could be categorised as persuasion from others. Other factors mentioned by teachers included: a student's self-confidence or self-belief (n = 6); the provision of tasks with an appropriate degree of challenge (n = 3); a student's intelligence or ability (n = 3); and the school's culture or ethos (n = 2). Compared with their earlier interviews, where five teachers explicitly acknowledged the potential influence of school and teacher on mathematics self-efficacy, 11 teachers talked about this, post-intervention.

As part of the mathematics self-efficacy intervention, teachers implemented several key strategies with their students, and reported a number of positive effects. Post-intervention, teachers showed a heightened awareness of how students' interactions with their peers, parents, and teachers can influence students' beliefs

about their abilities in mathematics. In the following section, students' and teachers' thoughts about the nature of intelligence are presented before discussing the effects of the second intervention, which aimed to increase students' incremental beliefs about intelligence.

What is intelligence?

> Researcher: Tell me what you think intelligence is.
>
> Student: Well, I think it's just a way that you inherit from your parents.
>
> Researcher: And what is it, exactly?
>
> Student: It's just a thing that you get better at, which means that some people aren't, well, they've got less to start with so they've got less when they've tried as hard as they could, when people who've got a lot just had to go up a teeny bit. The people with a little had to go up a whole lot to be with the higher people, and they just had to go up a little bit. (Year 4 girl, low theory-of-intelligence score)

A small number of students, like the one above, described intelligence as a combination of capacity and rate. Another student appeared to have given some thought to what intelligence is, and had developed his own tentative theory about intelligence having two distinct aspects:

> Student: I reckon there's kind of two types of intelligence. Basic intelligence, which is like being able to speak and communicate. And then, learned intelligence which you gain by learning things and doing things and exploring things.
>
> Researcher: OK. And where did you get that idea of there being two intelligences from?
>
> Student: Well, I kind of thought of it for myself. I can't remember it coming from anywhere else.
>
> Researcher: Uh-huh. Well, in the questionnaire that you did with me last term, it kind of looked as though you thought you can't really change your intelligence, although it seemed a little unclear, so I thought I'd ask you in the interview. Do you think that you can actually change your intelligence?
>
> Student: You can't really change your basic intelligence, but can change your learned intelligence. Coz you can't, well, you can kind of change your basic intelligence, like learning a different language, coz that's being able to communicate, but that's really adding to it actually, so sort of. (Year 5 boy, low theory-of-intelligence score)

The thoughtful responses made by these two students were exceptional among the student interviewees, and showed an emerging awareness of the complexity of intelligence and the factors that might define it. Both definitions were suggestive of intelligence as comprising the two dimensions described in Chapter 3: a more or less fixed capacity for learning, and the (softer) rate at which knowledge can be acquired. Both students had low theory-of-intelligence scores. Whether their low scores were representative of their beliefs about the malleability of both dimensions of intelligence, or whether they believed the rate of knowledge acquisition could be increased but the level of complexity could not, or vice versa, cannot be discerned from their questionnaire responses and was not asked during the interviews.

The first description in particular seemed to correspond with some of the comments teachers made about intelligence being an innate ability that can be developed to a limited extent, discussed shortly. Both students had low scores for theory-of-intelligence, and both scored among the highest 10% in the sample of 152 students for Time 3 mathematics achievement. Definitions of intelligence from other students with equally high achievement tended to be much more plainly stated, such as, “How smart you are” (Year 4 boy, low theory-of-intelligence score, high achievement). Being “smart” was included in definitions of students with a wide range of achievement levels. So students’ ideas about intelligence did not appear to be systematically associated with their achievement in mathematics.

Seven other students gave descriptions of intelligence that seemed to show emerging two-dimensional definitions of intelligence. These responses ranged from “Being smart and knowing a lot of things, a big variety of things, and learning fast” (Year 5 girl, high theory-of-intelligence score), to “Being good at maths and being good at other learning stuff as well” (Year 4 boy, high theory-of-intelligence score). The nine students with more complex definitions of intelligence than simply being “smart” had a range of theory-of-intelligence scores. Of the students with these more nuanced definitions for whom Time 3 data were available, four of the seven had achievement scores in the highest 10% of the sample of 152 students.

Students and teachers were all asked to describe what they thought intelligence was. Table 7.5 shows a summary of students’ responses, in which they tended to relate their ideas about what intelligence is directly to their personal experiences. Students often responded with a short statement, such as “Being clever” (Year 4 girl, low theory-of-intelligence score). Most frequently at Time 1, students described

intelligence as being smart or clever, or being good at something (*n* = 24). Equal numbers of students with low and high theory-of-intelligence scores made this type of response. This explanation seemed to be representative of intelligence as an inherent capacity, and was more often given by Year 4 (*n* = 15) than Year 5 students (*n* = 9). An awareness of the influence of a student's home environment was indicated when students commented that "Sometimes at night me and Mum tell each other simple maths problems" (Year 4 girl, low theory-of-intelligence score), or "You read a lot of books and do a lot of learning stuff at home" (Year 5 boy, high theory-of-intelligence score), when talking about what intelligence is.

Table 7.5: Students' definitions of intelligence

Summary of students' responses to "Tell me what intelligence is" at Time 1 (and Time 2, shown in parentheses) interviews, by theory-of-intelligence scores in their Time 1 questionnaire. Several students' responses fell into more than one category.

Students' definitions of intelligence	Low theory-of-intelligence score *n* = 22	High theory-of-intelligence score *n* = 23
How smart you are, being good at something	12 (9)	12 (14)
Influenced by home environment	4 (2)	4 (3)
Knowing, getting right answers	4 (2)	11 (6)
Effort	2 (1)	2 (0)
Other	2 (2)	3 (2)
Don't know	9 (7)	2 (3)

Of the 14 responses that suggested knowing or getting right answers were characteristics of intelligence, a greater number of these were made by students with high theory-of-intelligence score (*n* = 11), and more came from the older year level (*n* = 10). For instance, one Year 5 student defined intelligence as "When you know lots of stuff and you know all the answers" (Year 5 boy, high theory-of-intelligence score). Some students with high theory-of-intelligence scores seemed to believe knowledge was a component of, or synonymous with, intelligence, and because they believed they could increase their knowledge, they believed they could change their intelligence. It seems obvious that if a student believes intelligence equates with knowledge, then they will probably believe they can

change their intelligence. However, this does not explain why a small number of students with low theory-of-intelligence scores also described intelligence as related to knowing.

A small number of students mentioned effort when they described intelligence at Time 1; two were Year 4 students and two, Year 5. In her response to the question about intelligence, one student responded: “To have a go and to have a try and see if you get it right” (Year 5 girl, high theory-of-intelligence score).

Not all students were able to suggest what intelligence might be (*n* = 11); nine of these were students with low scores for theory-of-intelligence, and seven of the “Don’t know” responses came from Year 4 students. It is important to consider that, particularly at the first interview, this might well have been the first time that students had been asked to explain what intelligence is, so a “Don’t know” response may have been given by some students who felt unable to articulate their (simple or complex) understanding of intelligence. Some aspects of students’ definitions of intelligence varied according to their theory-of-intelligence scores, some according year level, and some by a combination of both attributes.

Table 7.6 shows the number of students whose definitions of intelligence were consistent with a definition of intelligence as malleable knowledge or as a stable capacity, or a combination of the two components. Year 5 students were more likely than Year 4 students to give a uni-dimensional definition of intelligence, either as malleable knowledge or as a stable capacity. Year 5 students with high theory-of-intelligence scores most frequently defined intelligence as knowledge-related. Students in both year levels, and with both low and high theory-of-intelligence scores, gave definitions that were consistent with intelligence as a fairly stable capacity. Younger students and those with low theory-of-intelligence scores gave definitions of intelligence that included both components – a malleable knowledge component and a stable capacity – more often than older students. However the small number of responses in this category should be interpreted cautiously.

Table 7.6: Students' definitions of intelligence as capacity and/or knowledge

Summary of students' definitions of *intelligence* at Time 1 (and Time 2, shown in parentheses) interviews, consistent with intelligence as a stable capacity, a malleable knowledge component, or both. Frequencies are presented by theory-of-intelligence scores in their Time 1 questionnaire, and by year level. Responses from 34 students at Times 1 and 26 of the same students at 2 are represented here. These definitions were classified as either "How smart you are, being good at something" or "Knowing, getting right answers" in Figure 7.5.

Students' definitions of intelligence	Low theory-of-intelligence score *n* = 14	High theory-of-intelligence score *n* = 20	Year 4 *n* =16	Year 5 *n* = 18
Malleable knowledge only	0 (2)	9 (2)	1 (2)	8 (2)
Stable capacity only	10 (9)	9 (9)	10 (11)	9 (7)
Malleable knowledge and stable capacity together	4 (0)	2 (4)	5 (1)	1 (3)

In Table 7.7, characteristics of intelligence that teachers explicitly talked about in their interviews are summarised. Most frequently mentioned by teachers in both groups (*n* = 13) was the idea of intelligence as an innate ability or capacity. Seven teachers referred to intelligence as a combination of the effects of an innate ability and the influences of a person's environment, with one teacher saying that "I think it's affected by your genes … It is affected by nurture as well as nature, it's just how much. I mean, there's scientific debate – how much can you change intelligence?" (Combined interventions group teacher J). Another teacher used a sandstone analogy to convey his thoughts:

> I think that intelligence, at least from a psychological standpoint, is pretty much set not completely in stone, maybe in some sandstone, so I think it can be etched a little bit this way and that way, but I think that, pretty much that's where it stands. … I don't think it can be changed to a large degree. (Mathematics self-efficacy intervention group teacher E)

Table 7.7: Teachers' definitions of intelligence

Summary of teachers' responses to "Tell me what intelligence is" at Time 1 (and Time 2, shown in parentheses) interviews, by treatment group. Some teachers' responses fell into more than one category. Note: "Combined interventions group" is the Combined mathematics self-efficacy and theory-of-intelligence interventions group.

Teachers' definitions of intelligence	Mathematics self-efficacy intervention group *n* = 8	Combined interventions group *n* = 7
Innate capacity/ability to think, problem solve, communicate, learn	7 (6)	6 (6)
Influenced by environment, experiences	5 (6)	3 (3)
Knowledge, how much you learn	2 (0)	1 (1)
Influenced by effort	1 (2)	0 (0)
Other	1 (1)	2 (1)
Unsure	0 (0)	1 (0)

The implication appeared to be that the genetic influence on intelligence determined the maximum potential limit of a person's intelligence, regardless of the opportunities provided in their environment, including school. The teachers seemed to perceive their role as helping students to maximise students' learning within their capacity to learn.

During the Time 1 interviews, two teachers described their beliefs that intelligence is an innate ability, but at their later interviews, were less definite about this. A teacher in the Combined interventions group explained her thoughts about what intelligence is at her first interview:

> Teacher: I think you're either born with intelligence or not. I'm never ever going to be able to be a doctor, I am not intellectual enough. If I had said, when I was an 8-year-old that I'm going to choose to be a doctor and I hated school, then no matter how intelligent I might've been, I would never have been able to get there.
>
> Researcher: And how do you think this belief affects your own learning?
>
> Teacher: Oh, it has stifled me. Believing that, I've often thought that maybe I can't do something. Like maths – didn't think I'd be able to teach maths, hopeless, didn't think that I'd be able to explain, take the kids through to the next step.

In the teacher's second interview, she was less sure that intelligence is completely innate:

> I still think it's something that you are born with, and probably if you have the spine or the interest, it can perhaps be improved. I'm still not sure about this one – are you born with intelligence, or can your circumstances make it change? I don't know, I still don't know.

She was particularly insistent, though, that her own beliefs about intelligence did not influence her interactions with her students, particularly students who might struggle with mathematics:

> No, no, no! Not for my class. Oh, absolutely not! They can all do everything really well, and if they can't, I'm going to try to help them to get it, to understand it well. We're starting multiplication and division this week and I know there's a couple of little girls, that they're just going to sit there and I'm going to see myself in them, and I'm going to put all my effort into moving them along. (Combined interventions group teacher N)

Comments made by one of this teacher's students suggested there was a particularly inclusive ethos in her class: "Because it's not no-one's really good at maths, it's <u>everybody's</u> really good at maths, it's just their learning, how much they've learnt about it. Coz our groups, there's no high group, we've just got a different learning step" (Year 4 girl, high theory-of-intelligence score). So from this student's perspective at least, this teacher might have been quite successful in masking her own beliefs about intelligence, in her interactions with students.

When students' and teachers' thoughts about what intelligence is were compared, some parallels and dissimilarities were evident. As might be expected, teachers' ideas about intelligence tended to be more clearly defined than those of students, and were described as more general principles, sometimes supported by examples from teachers' personal experiences. In some cases, students' descriptions of intelligence seemed to be naïve expressions of the characteristics of intelligence that teachers described, applied in the narrower context of the students' own experience. Some correspondence between the first three categories in Table 7.5 and the first three categories in Table 7.6, respectively, was suggested by the data. For example, the student's response that intelligence is "when a person is very good at maths and he or she is maybe a bit higher than they are supposed to be at maths at their level" (Year 5 girl, high theory-of-intelligence score) seemed akin to teachers defining intelligence as an innate ability. Teachers talked about intelligence being influenced by heredity and environmental factors, with some

referring to debates about the relative influences of nature and nurture. From students' perspectives, the environmental factor that was significant was specifically their home environment. Another parallel was that themes of knowledge and knowing were evident both in students' and teachers' definitions of intelligence.

Although effort appears in categories in both tables, it was used differently in each. One student expressed a belief in an inverse relationship between intelligence and finding learning difficult, saying that intelligence was "When you know all sorts of things and it's really easy for you" (Year 5 boy, high theory-of-intelligence score). Another student, though, perceived effort as a necessary component of intelligence: "I think intelligence is how good you are when you concentrate" (Year 4 girl, low theory-of-intelligence score). The latter response seemed more aligned with this teacher's inclusion of effort in her statement that "Hard work is related to intelligence" (Mathematics self-efficacy intervention group teacher A), suggestive of hard work enabling intelligence to deploy to its full effect. Overall though, there appeared to be a degree of connection between some of the students' and teachers' thoughts about what intelligence is, with the two students' explanations of intelligence that were quoted at the start of this section most closely resembling some of teachers' ideas.

(How much) Can intelligence be changed?

Most striking in students' interview data was their general endorsement of an incremental theory-of-intelligence, even by those whose questionnaire responses tended towards an entity belief. Table 7.8 shows a summary of students' theory-of-intelligence, as indicated in their interviews.

Students with the lowest questionnaire scores for theory-of-intelligence items were included in the interview sample because it was expected that their interviews would illuminate why they tended to believe that intelligence could not be altered. However, during interviews, almost all students expressed their thoughts about intelligence in terms of varying degrees of incrementality, rather than in absolute terms of "Yes, you can change your intelligence" or "No, you cannot change your intelligence". This did not support the interpretation of low questionnaire scores as representing an entity belief. To illustrate this point, this student had a low score for theory-of-intelligence, but expressed a belief that she could change her intelligence, to a degree:

Researcher: In the questions that you answered last term, it looks as though you thought that you can't really change your intelligence. Is that right?

Student: I'd say I could, just a little bit.

Researcher: And why do you think that?

Student: Coz I know most of the maths stuff [my teacher] gives us … I don't get much stuff wrong, but it's tricky when I have to go back and do it again, that's when I have to try and get a little bit better. (Year 4 girl, low theory-of-intelligence score)

Table 7.8: Students' theory-of-intelligence indicated in their interviews

Summary of students' Time 1 (and Time 2, shown in parentheses) interview responses when asked whether they thought they could change their intelligence, by theory-of-intelligence scores in Time 1 questionnaire. At Time 2, all students with low incremental scores at Time 1 were re-interviewed, as were the 19 students with high scores who were available.

Theory-of-intelligence indicated during interview	Low theory-of-intelligence score *n* = 22[6]	High theory-of-intelligence score *n* = 23
Incremental	17 (20)	22 (18)
Entity	0 (0)	0 (0)
Inconsistent response	3 (2)	0 (1)
Don't know, not sure	2 (0)	1 (0)

Of the other students who were selected because they tended towards an entity theory-of-intelligence in their questionnaire results, only one student gave a response in her first interview that did not seem to reflect an incremental theory, although neither did it appear to clearly endorse an entity belief. She explained that she thought she could not change her intelligence, "coz I think some of the work's hard that I do" (Year 4 girl, low theory-of-intelligence score). It seems likely that this student might not have understood what she was being asked and was classified as "Don't know".

When asked in his Time 2 interview if he thought he could change his intelligence, another student made a differentiation between changing and expanding intelligence, saying, "No, you can't change it, you can add to it" (Year 5 boy, high

[6] One student's Time 1 interview was interrupted twice, and the questions relating to their theory of intelligence were accidentally omitted. For this reason, the responses of 22 students with low theory of intelligence scores, rather than 23, are included in this section.

theory-of-intelligence score). This response was categorised as being in the spirit of an incremental theory, and supported his high score for theory-of-intelligence. A similar additive belief about intelligence seemed to be expressed by this boy, who had one of the lowest theory-of-intelligence scores:

> Student: I believe that you can change your intelligence a bit.
>
> Researcher: Tell me why you think this?
>
> Student: Well, you can put new intelligence in, but you can't push old intelligence out.
>
> Researcher: How do you know that?
>
> Student: Coz I know everything I've known since I was a baby. I didn't know anything when I was born, but when I first started to know things, I've been knowing them for 8 years … you can learn another thing, but you can't learn about something you already know about. (Year 4 boy, low theory-of-intelligence score)

This idea of intelligence as an acquirable knowledge component was also expressed by a student who explained he could increase his intelligence, "Coz if you learn more you can change it coz you're storing more stuff in your brain" (Year 4 boy, low theory-of-intelligence score). Students with a wide range of theory-of-intelligence scores appeared to conceptualise intelligence as an accumulation of knowledge. The mathematics achievement scores of these students tended to be in the lowest quarter of the range.

Three students initially agreed that they believed they could not change their intelligence, but when comments they made prompted me to repeat the question, they answered in the affirmative. At Time 2, similarly inconsistent responses were given by three students, only one of whom had done so at Time 1. Because the majority of students indicated in their first interviews that they believed they could change their intelligence to some degree, and because the quantitative data had shown what appeared to be a very gradual positive change in mean theory-of-intelligence over time for each treatment group (see Figure 6.2), there was almost no scope to detect noticeable shifts towards a more incremental theory-of-intelligence in students' Time 2 interview data. One implication was that in the case of the Combined interventions group, using the interviews to detect changes in students' theory-of-intelligence that might be attributable to the theory-of-intelligence intervention was problematic.

To eliminate the possibility of there being differences according to treatment group or year level, students' theory-of-intelligence indications from their interviews were summarised accordingly (see Table 7.9). This confirmed that 14 of the 15 students in the Combined interventions group appeared to have an incremental theory-of-intelligence in their interviews. The only student in this group who was unsure about the malleability of intelligence in her first interview, scored in the top one-third of students for Time 1 theory-of-intelligence and expressed incremental beliefs at her second interview. When asked to confirm that the student thought she could change her intelligence quite a lot, she replied, "Yeah, coz you can always do more when you practise and you study" (Year 5 girl, high theory-of-intelligence score).

Table 7.9: Students' theory-of-intelligence indicated in their interviews, by year level and treatment group

Summary of students' theory-of-intelligence, as described in their Time 1 (and Time 2, shown in parentheses) interviews, by year level and treatment group. At Time 1, 45 students were interviewed about their theory-of-intelligence, and at Time 2, 41. Note: "Combined interventions group" is the Combined mathematics self-efficacy and theory-of-intelligence interventions group.

Theory-of-intelligence indicated during interview	Year 4 *n* = 23	Year 5 *n* = 22	Control group *n* = 14	Mathematics self-efficacy intervention group *n* = 16	Combined interventions group *n* = 15
Incremental	20 (20)	19 (18)	11 (11)	14 (12)	14 (15)
Entity	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Inconsistent response	1 (2)	2 (1)	2 (2)	1 (1)	0 (0)
Don't know, not sure	2 (0)	1 (0)	1 (0)	1 (0)	1 (0)

To investigate the extent to which a variability in definition of the term *intelligence* might have affected the apparent differences between the questionnaire and interview responses of the students identified as having low theory-of-intelligence scores, all students' responses to "Tell me what intelligence is" were examined (see Table 7.5). At Time 1, the most frequent response (*n* = 9) from students with low theory-of-intelligence scores was that they did not know what intelligence is. In the second interviews, this persisted for seven of these students. Thirteen other students with low scores, however, expressed ideas that seemed related to intelligence, so a lack of understanding of the term did not account for their questionnaire responses being at odds with their interview answers. A much

smaller number of students with high theory-of-intelligence scores (*n* = 2) was unable to describe intelligence.

The theory-of-intelligence items in the questionnaire were stated in absolute terms (either you can or you can't change your intelligence), but from students' comments during the interviews, it seemed that a number of them had a more nuanced interpretation of the malleability of intelligence. It was not until students were asked for their ideas about how intelligence could be changed that their thoughts about the rate at which they could acquire knowledge emerged. Among the students there seemed to be a range of beliefs about how much, and how quickly, intelligence might change. When some students' positive responses to the question "Do you think you can change your intelligence?" were probed, their comments related to how much a person could change their intelligence to different time periods. These ranged from weeks: "Because, say you're not really that smart at doing maths, then over a few weeks you get really smart" (Year 5 girl, low theory-of-intelligence score); to a school term: "Maybe a little bit each term" (Year 4 girl, low theory-of-intelligence score); to a year: "Per day it would be not very much, but for a year, definitely a lot. Because last year I didn't know square roots and now I do" (Year 4 boy, high theory-of-intelligence score). This suggested that rather than asking simply if a student believes they can change their intelligence, it might be more revealing to ask them to explain how much they thought it could be changed, or how much time it might take.

Part-way through the data-gathering, therefore, a question was added to the interview, asking students who had indicated a belief in the malleability of intelligence, "How much do you think you can change your intelligence?" Thirty-five students responded to this question at Time 1, and 34 of the same students at Time 2. Their responses fell into two groups. First, those who were sure that intelligence could be substantially increased. One Year 4 student thought:

> Because when I was little I used to draw a lot and then I wasn't very good, and then I drew a lot – like tons every day – and now I'm a pretty good artist. So I think if you try you can get better at anything you want. (Year 4 boy, high theory-of-intelligence score)

Another said, "If you practise and practise you can change it, and then you can change your confidence as well as your intelligence" (Year 4 girl, high theory-of-intelligence score). These students appeared to have a relatively strong incremental theory-of-intelligence.

A second group included those who, although they seemed to think that they could increase their intelligence, were also aware of factors that limited this potential. A student who thought she could change her intelligence "just a bit", explained that applying effort could make a difference: "Maybe if you usually don't really listen that well, you can try and do your best, try harder" (Year 5 girl, low theory-of-intelligence score). Another said intelligence could be changed "A little bit, but not very much coz you can still be the same self as you are" (Year 4 girl, high theory-of-intelligence score). One student's response suggested that changes in what she thought was intelligence needed to keep in step with a student's age, and that knowing more than a student should at a given age could have negative consequences:

> Just enough as your age goes. Coz if you get too hard when you're a senior, like a Year 6, then you'll know too much and you'll have to move on, and you won't be old enough, and well, then you'll get mixed up. (Year 4 girl, low theory-of-intelligence score)

Table 7.10 shows how many students' responses about the malleability of their intelligence indicated an incremental theory-of-intelligence with an awareness of possible limitations, and how many seemed to believe intelligence could be increased substantially.

Table 7.10: Theory-of-intelligence of a sub-sample of students

A sub-sample of 35 students' theory-of-intelligence as indicated in their Time 1 (and Time 2, shown in parentheses) responses to "How much do you think you can change your intelligence?", by theory-of-intelligence scores in their Time 1 questionnaires. Thirty-four students' Time 2 responses are included. Each student had already indicated a belief that intelligence could be changed.

Theory-of-intelligence indicated during interview	Low theory-of-intelligence score	High theory-of-intelligence score
Strongly incremental	2 (4)	19 (11)
Incremental, with limitations	12 (10)	2 (9)

The Time 1 interview responses suggested that students who had low scores for the first questionnaire tended to be those whose interview comments were indicative of an incremental theory-of-intelligence with limiting factors, rather than a distinct entity theory. At Time 2, though, the balance of responses from students with high theory-of-intelligence scores shifted, so that a similar number suggested limiting factors as the number who indicated they believed their intelligence was very malleable. From these data, it seems that the low/high theory-of-intelligence

distinction was at least partly characterised by a difference in students' definitions of intelligence, which related to how much students believed intelligence could change – not whether or not it could. So not only did students have various definitions of *intelligence*, they also varied in opinion as to how much intelligence – as they defined it – can change.

Differences according to year level were also evident, with eight Year 4 students indicating a strongly incremental belief at Time 1, compared to 13 Year 5 students. More Year 4 students (n = 11) than Year 5 (n = 3) indicated an incremental belief, with limitations.

Students were asked to describe how they thought they could change their intelligence. Their ideas are summarised in Table 7.11. Although separate categories were included for effort-related responses, learning, and self-belief, there was some overlap between these. For instance, this student's response was coded as both "effort" and "learning": "Learning a lot and trying hard to learn and practising" (Year 5 girl, high theory-of-intelligence score).

Table 7.11: Students' beliefs about how intelligence can be changed

Summary of students' responses to "How can you change your intelligence?", as indicated in their Time 1 (and Time 2, shown in parentheses) interviews, by theory-of-intelligence scores in their Time 1 questionnaires. Several students' responses fell into more than one category.

Ways to change intelligence	Low theory-of-intelligence score n = 22	High theory-of-intelligence score n = 23
Effort	13 (9)	17 (11)
Learning	5 (14)	9 (6)
Self-belief	2 (0)	1 (2)
Other	3 (7)	2 (7)
Don't know	4 (0)	0 (0)

At Time 1, effort-related suggestions were the category of response made most frequently by both groups of students. Students' Time 2 responses were less likely than those made at Time 1 to include the belief that they could alter their intelligence by applying effort, or practising. Instead, a greater number of students who had low theory-of-intelligence scores at Time 1 responded that they could increase their intelligence by learning. One said, "Yes, I think I can, by learning new stuff about multiplication and division and next year I'll learn more and get smarter"

(Year 5 girl, low theory-of-intelligence score), while another responded, “Coz you can learn more things and then that makes you a bit smarter, more intelligent” (Year 4 boy, low theory-of-intelligence score). Another student who thought he could increase his intelligence by learning, commented, “Because I’ll learn a bit at a time, and I’ll keep on getting smarter and smarter at the end” (Year 5 boy, low theory-of-intelligence score). All of these students seemed to use intelligence synonymously with learning and gaining knowledge. For students with high theory-of-intelligence scores, both effort and learning were mentioned less frequently in their second interviews than in their first.

Classified as “Other”’ at Time 1 were a variety of comments that appeared unrelated to the categories above, and to one another. For instance, one Year 4 boy responded that he could change his intelligence by “Watching documentaries and watching ‘I Shouldn’t Be Alive’ to learn how to avoid things” (Year 4 boy, low theory-of-intelligence score). Additional responses classed as “Other” were, “By getting lots of help really, coz you can’t do it by yourself all the time” (Year 5 girl, high theory-of-intelligence score), and “By having different feelings inside you” (Year 4 girl, high theory-of-intelligence score).

At Time 2, five of the 14 “Other” responses made a link between teachers presenting students with challenging work and changing their intelligence, in what may have been an emerging category which was not evident in the earlier interviews. “Because [my teacher] keeps on doing harder questions, and it makes me really think about it, and makes me smarter” (Year 5 girl, low theory-of-intelligence score) was one response in this category. Another student suggested his intelligence would be increased by his teacher “giving me hard maths like twelve times thirteen, or twelve times twelve” (Year 4 boy, high theory-of-intelligence score). Comments in this category suggested students had some awareness of the value of being presented with challenges. Students’ ideas about how they could increase their intelligence were also examined for each year level, but there were no noticeable differences between Year 4 and Year 5 students’ responses in any category.

In students’ interview data, there was further evidence to confirm that theory-of-intelligence beliefs are not dichotomous. No students stated that they definitely believed intelligence could not be altered, although a small number of students seemed unsure. This largely matched the quantitative data in which very few extremely low theory-of-intelligence scores were evident. Rather than expressing

either entity or incremental beliefs, students' beliefs about the malleability of intelligence were influenced by their definitions of intelligence. Furthermore, students expressed a range of beliefs about the degree of malleability of intelligence, as they defined it. Students' high theory-of-intelligence scores tended to be associated with a view of intelligence as either knowledge/skill or a capacity for learning, and low theory-of-intelligence tended to be associated with either a capacity for learning or a combination of both knowledge and capacity components.

Table 7.12 shows students' responses to the question, "Do you think your teacher believes that children can change how intelligent they are?" The majority of students answered affirmatively at Time 1 (38), with this number decreasing slightly at Time 2 (33 students). To some students, it seemed obvious that teachers would think this way. Several students believed that their teachers thought students could change their intelligence, "Because she is a teacher and she wouldn't really be doing it if she doesn't think people can ... it would be a waste of time, basically" (Year 5 girl, high theory-of-intelligence score). One boy's response was, "Yeah, coz otherwise they wouldn't have maths sessions, coz they wouldn't think you could manage to get any further" (Year 4 boy, high theory-of-intelligence score). A Year 5 student's comment summed this up: "I think all teachers do" (Year 5 girl, low theory-of-intelligence score).

Table 7.12: Students' ideas about teachers' theory-of-intelligence

Summary of students' Time 1 (and Time 2, shown in parentheses) responses to "Do you think your teacher believes that children can change how intelligent they are?" by theory-of-intelligence scores in their Time 1 questionnaires. At Time 1, 44 students were asked this question, and at Time 2, all 41 students who were interviewed were asked.

Students' responses	Low theory-of-intelligence score	High theory-of-intelligence score
No	0 (1)	1 (1)
Don't know, unsure	2 (1)	2 (2)
Probably	1 (2)	0 (1)
Yes	18 (18)	20 (15)

A summary of teachers' beliefs about intelligence is shown in Table 7.13. At both interviews, the majority of teachers described beliefs that intelligence can be changed, some teachers tempering this with the limitations they perceived, and a smaller number talking even more positively about changing students' intelligence, with no mention made of any restrictions. For instance, a teacher indicated a strongly incremental theory-of-intelligence when she said:

> I think the biggest thing is that you don't set a ceiling on where they can get to, that every bit of learning leads to more learning, and it doesn't matter which student it is, they've all got room for growth. (Combined interventions group teacher L)

Table 7.13: Teachers' theory-of-intelligence indicated in their interviews

Intervention teachers' theory-of-intelligence at Time 1 (and Time 2, shown in parentheses) as expressed in their interviews, by treatment group. Note: "Combined interventions group" is the Combined mathematics self-efficacy and theory-of-intelligence interventions group.

Theory-of-intelligence indicated during interview	Mathematics self-efficacy intervention group *n* = 8	Combined interventions group *n* = 7
Strongly incremental	0 (1)	2 (2)
Incremental, with limitations	8 (7)	2 (3)
Entity	0 (0)	3 (1)
Unsure	0 (0)	0 (1)

In another case, a teacher's strong incremental belief was related to a family member's experience:

> When my Dad had a stroke … and he could hardly talk and he couldn't read, and he taught himself to read from the little red books right through to library books, and he taught himself to talk … that always tells me you can get these kids' brains developing. (Combined interventions group teacher K)

Another teacher in the Combined interventions group also described an entity theory-of-intelligence at her first interview, defining intelligence as "people's natural ability to pick up new concepts and the speed at which they can do it, and the rate at which they can retain it and then apply it over different areas". At her second interview, the way she explained intelligence suggested a belief that intelligence had some potential to be increased, with limitations:

> I think even if you're really, really smart and really intelligent, and can pick up concepts quite quickly, I don't necessarily think you're going to increase the quickness of that picking-up a whole bunch, coz if you're already up there – you know. I think it's probably not going to be a shift from zero to nine, you'll maybe process things a little bit faster as you go along, but I don't think it's going to be in giant leaps and bounds … if you think about intelligence as knowledge – I don't completely think that – but then the knowledge can increase. (Combined interventions group teacher P)

This teacher also said that her expectations of students were changing, and that, as a result, she was providing them with a less restrictive mathematics programme. Rather than thinking "You're just a stage 5 so you're just doing this, I've made sure that I've had opportunities for all of the kids to try something quite a bit harder, and a lot of them have actually succeeded in that" (Combined interventions group teacher P).

A teacher in the same intervention group perhaps came closest to expressing an entity theory-of-intelligence, although the influence of environmental factors was also acknowledged. In her first interview, she explained that:

> You're born with a capacity for understanding certain things, and your environment that you first grow up in is so important to how you think and how you develop that I feel once they get to school, you can't change too much, you can help encourage and be positive, and help understand, but that basic intelligence is set up very early on, and it takes a lot of effort to go beyond that and to help someone who maybe didn't have the same early start. (Combined interventions group teacher M)

Her thinking seemed unchanged at Time 2:

> What I still find difficult with the intelligence thing is those children that just never seem to get it … and that to me makes me think that there may be – this sounds really bad – but may be less potential at the start, whereas I feel that some of these kids, like their basic intelligence is there and while that doesn't mean they're going to pick up everything instantly, if you just give them a variety of ways, it will spark them off … that's been my big thing with why I think intelligence is fixed. (Combined interventions group teacher M)

Most teachers in the Mathematics self-efficacy intervention group described similar beliefs about intelligence at both interviews. Of the three teachers in the Combined interventions group who indicated an entity theory-of-intelligence in their first interviews, two seemed to have changed their thinking slightly at their second interviews; one expressed doubts about intelligence being purely innate, and the other indicated that, within limits, intelligence might increase. Compared to the students' beliefs, teachers expressed more clearly-defined ideas about the malleability of intelligence. A belief that intelligence cannot be altered was clearly asserted by more teachers than students, which might be related to teachers having more clearly defined ideas about what intelligence is. Like the students, though, teachers' beliefs varied according to how much they seemed to believe intelligence could be increased.

Participants' experiences of the theory-of-intelligence intervention

> Researcher: And how do you actually know that the brain lessons helped your learning in maths? How can you be sure?
>
> Student: I can be sure because ever since then I've got more of my maths working right which is probably because I've been exercising my brain and diving deeper. (Year 4 girl, Combined interventions group)

The effects of a short series of lessons about the brain (see Appendix D) are described here by the students and teachers in the Combined mathematics self-efficacy and theory-of-intelligence interventions group. In the Time 2 interviews, 14 students were asked about the lessons focusing on brain function and how the brain could be strengthened, which their teachers had undertaken to teach. To begin this part of the interview, they were asked what they recalled about the lessons. Several students, like this one, described the resources teachers used to support their learning, including "A brain, a pull-apart one, so she told us all the parts of the brain and she brought some posters, and one of the posters told us how to get smarter, just practise" (Year 5 girl).

Other students remembered different aspects of the lessons their teachers had taught, with one boy clearly interested in the language associated with the brain from the way he reported that he had learnt about "The different parts of the brain like the thalamus, the cerebellum, cerebrum, and how fast the messages from your brain travel through your system, 300 ks per second, or something like that" (Year 5 boy). A younger boy described the practical implications of particular information that was memorable for him:

> We learned about the parts of the brain and learned about a few things like cells, and what the pieces of the brain do. One of them makes you be able to balance, and one of them going down to your neck gives you the power to actually move, and if that snaps – well, paralysed, dead! Gone! (Year 4 boy)

When students were asked how the lessons had affected their learning, eight responded positively, and six of these students associated the brain lessons with perceived improvements in their mathematics performance. One girl justified her positive response by saying "Coz I get lots more things right" (Year 5 girl). Another student explained that she was "finding things easier to do, and I'm actually concentrating harder", and that as a result, she found "I get more work done by the end of the maths session" (Year 5 girl).

Although all the students remembered this series of lessons with their teacher, four students either could not recall learning anything about how they could make themselves smarter, with one boy suggesting the lessons had a different focus: “It was more how the brain works than how to change your brain, sort of” (Year 5 boy).

The seven teachers in this treatment group were also asked for their thoughts about the effectiveness of the brain lessons they had been asked to teach. Five teachers said they had spent around 2 hours on the lessons, with one teacher spending just 30 minutes and another, 1 hour. Perhaps not surprising was the fact that the teacher who devoted the least time to this intervention had indicated an entity theory-of-intelligence in her first questionnaire and interview.

The idea of students thinking they had some control of their brains as a result of the intervention lessons was mentioned by three teachers. One described how she believed that as a result of the brain lessons, students “saw that they had some control over what they were doing and how they could learn” (Combined interventions group teacher L). Another teacher echoed this, saying that her students “were just enthralled, they were just so excited about the whole brain concept, and that they actually had control of it. They loved it … I think they feel they’re more in control of their learning” (Combined interventions group teacher M).

Related to students feeling they had some control of their brains was the concept of building connections within the brain. This was mentioned by several teachers, along with the empowering impact it had had on some students. For one teacher, making connections seemed to have become part of the learning-related language that was used in her class: “Now when they’re learning something, they talk about making a new connection. I think that was the biggest thing for them, that they see that they actually can make a difference” (Combined interventions group teacher L). Teachers devised their own ways of making the idea of connections in the brain meaningful for students, with two using pathways analogies. One talked about sheep tracks that became well established with regular use, to highlight the strengthening effect of practice on synapses in the brain. A second teacher included herself in a GPS analogy, explaining to students that she provided guidance when students first travelled an unfamiliar route, but that after they had travelled that route a number of times, the GPS would become redundant because they knew their way independently.

Another teacher was excited to see one of her students writing about connections, and emailed me to let me know that "Yesterday we were doing some challenging work on identifying factors. At the end the children wrote a reflection on how they felt after this activity. One child wrote "It feels like a connection is connecting" (email from a Combined interventions group teacher M). The idea of building connections in the brain was also described by students during their Time 2 interviews, and is illustrated by this girl's explanation of her understanding of the effect of learning on the brain:

> We learnt how when we learn new stuff, it creates a new pathway in our brain, connecting two cells, but if we don't keep going over it, then the connection doesn't really stay, so we've got to keep practising to make the connection stronger. (Year 5 girl)

Several teachers commented that they intended to include a focus on building connections in the brain at the beginning of the following school year, because they believed it had had positive effects on their students' learning in all areas, including mathematics. One teacher said "I think some of that brain work I'll do from the start of the year, and actually get them to see that they can make a difference … what they do contributes to what they achieve" (Combined interventions group teacher L). Likewise, another was going to highlight "The same sort of learning pathways, and creating new learning in our brains, and that we're getting more intelligent the more we learn and make connections" (Combined interventions group teacher P), as part of establishing her classroom culture at the beginning of the year. Other teachers' plans for the start of the next year included giving consideration to how students could be grouped in ways that might support their mathematics self-efficacy, and teaching students about how the brain works, using some of the resources provided during the intervention.

Teacher change was not explicitly investigated during the interviews. A teacher with around 20 years' experience talked briefly about change being difficult. When she responded to a question about the challenges in implementing the interventions, she said the biggest challenge had been "Changing my behaviour. When you've been teaching a long time, it is difficult sometimes to undertake new learning" (Combined interventions group teacher O). Her questionnaire scores for theory-of-intelligence items were almost identical on both occasions (32 of a possible 48 total points at Time 1, and 33 at Time 2). Interestingly though, when she was asked to

comment on how the start of the next school year in her classroom might be different to the start of the current year, this teacher said that:

> I think I'll have more belief in their ability to change their intelligence through the year. I won't perhaps see them in quite such tight little groups – these are the slow group, this is the medium group … so I'd like to see more movement between each group ... I think my expectations for them to make a difference to their intelligence through the year will be greater. (Combined interventions group teacher O)

It was not possible to know whether this teacher's beliefs about intelligence had changed in a way that would endure, or whether this would have any effects on her interactions with students.

Looking at the overall effects of this intervention, a small number of students reported improvements in their mathematics learning that they suggested was related to the theory-of-intelligence intervention. Although this may have been the case for some individual students, the overall quantitative analysis revealed no effect of treatment group on students' mean theory-of-intelligence, although it did show that students in the Combined interventions group had the highest mean mathematics achievement at each data collection point (see Figures 6.2 and 6.3, respectively).

Teachers also seemed to think that the intervention lessons had made a difference for some students' learning, particularly in giving some students a greater sense of control of their learning, and an understanding that practice is necessary to establish lasting connections in the brain. The teachers whose comments indicated they believed the brain lessons had merit talked about their intention to incorporate them into their start-of-year planning to help establish their expectations for students' learning over the year. The intervention and its associated professional development, however, appeared to have had little effect on teachers' beliefs.

Chapter summary

The qualitative findings helped to explain the nuances of students' and teachers' beliefs, and the effects on these of the interventions. Students' responses to interview questions about their mathematics self-efficacy indicated that their perceptions of task difficulty levels were associated with their self-efficacy beliefs. Teachers described the positive effects on students of implementing particular strategies intended to build their mathematics self-efficacy, particularly increasing their use of descriptive teacher-student feedback and using similar peers as models during mathematics. Students confirmed that observing similar, or more advanced, peers as models contributed to their mathematics learning, and seemed to be pleased that teachers included students of all abilities in peer modelling.

Grouping students for mathematics instruction according to their strategy stages – a form of ability grouping – was perceived to have negative consequences for students who were less able mathematicians. Several teachers responded to this by experimenting with alternative groupings. However, it seems likely that the less able students who one teacher referred to as "always a Triangle" in fixed, ability-based groups might simply become the students who are in the "people who aren't sure" category in alternative, fluid groupings. Whether alternative instructional management structures might have a more positive effect on all students' mathematics self-efficacy than ability grouping in the long term, warrants further investigation.

Signs of entity beliefs were more readily identifiable in comments about intelligence made by a small number of teachers than in responses from students, who typically described a variety of incremental beliefs. Two types of incremental beliefs seemed to emerge from the students' and teachers' interviews. First, beliefs were described that included some limiting factor, such as genetic inheritance or in the case of students' perspectives, time. Teachers most often described this kind of belief. Among the younger students, a belief that how much intelligence can be increased is limited appeared to be more prevalent than with older students. Secondly, a more optimistic belief that intelligence could be changed substantially with no particular restrictions, was more common among the older students interviewed, and a very small number of teachers. The extent to which the boundaries were blurred between these two types of incremental belief was not observable in the data. It is unclear whether an entity belief that a person inherits their intelligence and cannot change it can be clearly differentiated from an incremental theory with

limitations – a person inherits their intelligence but can change it, within limits. What was clear, though, was that talking about people as being either entity or incremental theorists is overly simplistic, masking a diversity of definitions of intelligence and beliefs about the degree to which it can be changed.

Students' responses to questions about intelligence illuminated the complexity of their beliefs, and revealed two variables: how students defined intelligence, and how malleable they believed intelligence (as they defined it) actually is. The pattern that was consistent across the whole sample, regardless of theory-of-intelligence score or year level, was that students most frequently defined intelligence as a capacity to learn. How the findings from the qualitative data summarised here compared with those from the quantitative data, is discussed in the following chapter.

CHAPTER 8
Discussion and Conclusions

Evidence of intervention effects

The main aim of the study was to determine what effects two interventions had on students' mathematics self-efficacy, theory-of-intelligence, and mathematics achievement, over time. More specifically, the study sought to answer the question:

> *Over the three data collection points, do individual student differences in mathematics self-efficacy, achievement, and theory-of-intelligence vary as a function of treatment group?*

An important finding was that the evidence supported the hypothesis that the mathematics self-efficacy intervention would have a significant positive effect over time on the mean self-efficacy and achievement of students in the Mathematics self-efficacy intervention group. This was consistent with the findings of Siegle and McCoach (2007). Significant interactions of time and treatment group indicated that the significantly lower mathematics self-efficacy and achievement of the Mathematics self-efficacy intervention group that was evident at Time 1 was no longer evident at Time 3. The three strategies that most teachers in the Mathematics self-efficacy intervention group reported implementing with their students were: increasing their use of similar peers as models; increasing their use of descriptive teacher-student feedback; and providing students with strategies for coping when learning becomes difficult. Teachers raising their expectations of students' learning and becoming more willing to press students to work through difficult problems, rather than allowing them to abandon them, were also themes.

Despite the significant effect of the mathematics self-efficacy intervention on the mean mathematics self-efficacy of the Mathematics self-efficacy intervention group, there was no evidence of such an effect for the Combined interventions group. This might be associated with the significantly lower mean self-efficacy, pre-intervention, for the former group compared with the latter, arguably providing the self-efficacy intervention group greater potential than the combined group for increasing their self-efficacy beliefs. However, a more likely explanation might be related to the difference in pre-intervention mathematics achievement of the two groups. In their meta-analysis, Multon et al. (1991) observed that students with low achievement seemed to benefit most from self-efficacy interventions. Given that the mean

mathematics achievement for the Mathematics self-efficacy group was significantly lower than achievement in the two other groups when the present study began, this might partly explain the difference in the self-efficacy trajectories for the two groups.

Another factor that might have strengthened the impact of the intervention for the Mathematics self-efficacy intervention group, is that one medium-size school's entire teaching staff participated in all the intervention group meetings as their school-wide professional development focus for the year. This potentially provided those teachers with the collegial support and commitment to a shared purpose that Timperley et al. (2007) highlighted as necessary ingredients for changing teachers' practice. The Combined interventions group, in contrast, comprised a single teacher at one school and groups of three and four teachers at two other schools, all of which were larger schools with at least 400 students each. These teachers may not have had the same opportunities for collegial support, and were also participating in additional school-wide professional learning and development.

An alternative explanation for the different effect for the Combined interventions group is that the theory-of-intelligence intervention might have interfered with the mathematics self-efficacy intervention in some way. Whatever the underlying reason for the disparate findings, the change in self-efficacy for the Mathematics self-efficacy intervention group shows that the self-efficacy intervention was effective for these students.

There was no substantial evidence for the efficacy of the theory-of-intelligence intervention, aimed at developing more of an incremental belief about the malleability of intelligence. The lessons about the functioning of the brain were memorable for some students, particularly the idea that learning resulted in new connections being formed in the brain. In their interviews, several teachers and students commented about observed improvements in mathematics achievement. However, the quantitative data for the 152 students did not identify systematic positive effects for students in this group; the intervention may have had an impact on particular students, but no widespread change in theory-of-intelligence was detected by the theory-of-intelligence instrument.

Students in the Combined interventions group did not show increased theory-of-intelligence scores, mathematics self-efficacy, and achievement, more than students in the Mathematics self-efficacy intervention group or the Control group,

as had been hypothesised. The findings from the present study, therefore, were not consistent with those of Blackwell et al. (2007).

Effects of gender and year level

> *Among teatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of gender or year level?*

Overall, mean scores for mathematics self-efficacy, theory-of-intelligence, and achievement increased from Time 1 to Time 3 for girls and boys, and for Year 4 and Year 5 students, in all treatment groups. What stood out in regard to the hypothesised between-group differences according to gender and year level were initial significant differences in self-efficacy and achievement for students in the Mathematics self-efficacy intervention group, that had diminished by the final data collection point.

For girls, there was no evidence to support hypothesised between-group differences. For boys, there was a significant effect of treatment group. At Times 1 and 2, boys in the Mathematics self-efficacy intervention group had significantly lower mean mathematics self-efficacy and achievement than did boys in the remaining groups. The delayed post-intervention measures showed that between-group differences for boys did not persist, suggesting the effectiveness for these boys of the mathematics self-efficacy intervention.

For Year 4 students' mathematics achievement, a significant interaction between time and treatment was evident. The mean achievement of Year 4 students in the Mathematics self-efficacy intervention group was lower than that of their peers in the two other groups until Time 3. This between-group difference in achievement was even more clearly defined for Year 5 students in the Mathematics self-efficacy intervention group. In addition to significant effects of time and treatment group, and significant interaction effects for mathematics achievement, similar significant effects were evident for their mathematics self-efficacy. These significant between-group differences were no longer evident at Time 3. These findings also suggest the mathematics self-efficacy intervention had a positive effect on the achievement and self-efficacy of students in the mathematics self-efficacy intervention group, as had been hypothesised.

Within treatment groups, do individual student differences in mathematics self-efficacy, theory-of-intelligence, and mathematics achievement vary as a function of gender or year level?

Within individual treatment groups, no consistent effects of gender were indicated. Only in one group was there support for the hypothesis that boys' self-efficacy would be higher than girls' self-efficacy. In the Combined interventions group, boys' mean mathematics self-efficacy was significantly higher than that of girls, consistent with the findings of Lloyd et al. (2005), whose participants included students of a similar age. There was no significant difference in boys' and girls' mean alignment of mathematics self-efficacy and achievement, indicating no consistency between the findings of the present study and those of Ewers and Wood's (1993) study, in which 10 and 11-year-old boys tended to over-estimate their abilities more than girls.

The hypothesised gender difference in theory-of-intelligence, identified in studies by Dweck and Leggett (1988), Räty et al. (2004), and Stipek and Gralinski (1991), was not evident in the three groups of students. In the Control group, an initial significant difference between the boys' and girls' mean scores for theory-of-intelligence was no longer evident at Time 2. In contrast, boys' mean theory-of-intelligence was significantly greater than girls' theory-of-intelligence at Time 3 only, for the Mathematics self-efficacy intervention group. These one-off significant differences might be associated with the theory-of-intelligence instrument's capacity for accurately measuring students' beliefs about the malleability of intelligence. Importantly, the hypothesis that there would be no significant differences in girls' and boys' mathematics achievement was supported by the quantitative data, consistent with Young-Loveridge's (2010) findings.

The mean achievement of Year 5 students was higher than that of Year 4 students, in line with expectations based on Darr et al. (2007). Although most of the significant within-group differences associated with year level involved mathematics achievement and self-efficacy, the quantitative data did not support the hypothesis that Year 4 students would show stronger mathematics self-efficacy than Year 5 students. On the contrary, Year 5 students in the Combined interventions group had significantly greater mathematics self-efficacy than Year 4 students on all three occasions.

The quantitative data did not convincingly support the hypothesis that Year 4 students would tend to have a stronger incremental theory-of-intelligence than Year 5 students. Although year level showed no significant effect in the Control and Combined interventions groups, significant differences according to year level for theory-of-intelligence were indicated for the Mathematics self-efficacy intervention group, in which the mean for Year 4 students exceeded that of Year 5 students. This difference provided only limited support for the hypothesis, consistent with previous studies' findings (Ablard & Mills, 1996; Dweck & Elliott, 1983; Leonardi & Gialamas, 2002; Kurtz-Costes et al., 2005; Pintrich & Schunk, 1996).

Relationships among the student variables

How are students' theory-of-intelligence, mathematics self-efficacy, and mathematics achievement related?

Across the three groups, moderate-to-strong positive correlations between students' mathematics self-efficacy and achievement were fairly consistent, as hypothesised. Regression analyses showed that for students in the Mathematics self-efficacy group, post-intervention self-efficacy was associated with greater proportions of the variance in mathematics achievement at Times 2 and 3 than it was for the two other groups. There appeared to be something of a spiral effect for this group, with increased achievement building self-efficacy, which in turn strengthened subsequent achievement for students in the Mathematics self-efficacy intervention group. This is consistent with previous findings that self-efficacy predicts achievement (for example, Chen, 2003; Pajares & Graham, 1999; Schunk, 1981), and also that achievement predicts subsequent self-efficacy (Feltz, 1982; Usher & Pajares, 2009).

A few moderate correlations between self-efficacy and theory-of-intelligence were identified, but the systematic association between them that had been hypothesised was not evident. This finding was inconsistent with those of Chen and Pajares (2010), and Wood and Bandura (1989). The Time 3 correlations, in particular, might be associated with older students, more than younger students, defining intelligence as (malleable) knowledge. Although it seems possible that as students got older, the relationship between their self-efficacy and (so-called) theory-of-intelligence might have strengthened, problems with the theory-of-intelligence measure discussed shortly make reliable interpretation of the resultant data doubtful.

Mathematics self-efficacy change over time

The mean mathematics self-efficacy of students in the three groups increased over time, consistent with a trend identified in Zimmerman and Martinez-Pons' (1990) cross-sectional study, whose participants were at least 10 years old – slightly older than the 7 to 9-year-olds in the present study. Each treatment group's mean mathematics self-efficacy exceeded their mean achievement at each of the three data-collection points. Alignment of self-efficacy and achievement was closer towards the end of the school year than at the beginning of either of the two school years encompassing the study. The closer alignment is attributable to the increase in achievement for all groups from Time 1 to Time 2 being greater than their increase in self-efficacy.

In contrast, from the end of one school year to the start of the next, the increase in students' self-efficacy exceeded their increase in achievement, perhaps reflecting students' optimism at the start of a school year. Students were presented with the same mathematics problems at the end of the year as they had been shown seven months previously, so the problems may have seemed familiar to them on the second occasion. Although this might be expected to boost their self-efficacy, students were probably aware on this second occasion that they would subsequently be expected to solve the problems, and may have made more cautious self-efficacy judgments as a result. On the third occasion that they completed the self-efficacy measure, however, no such caution was evident. It seems likely that, at the end of the school year, when the gap between self-efficacy and achievement levels was smallest, students had probably developed a more accurate idea of their capabilities as a result of an accumulation of assessment information and teacher-student feedback about their progress over the course of the year.

Relationships between the student and teacher variables

Is there a correlation between a teacher's theory-of-intelligence and their students' theory-of-intelligence?

Is there a correlation between a teacher's self-efficacy for teaching mathematics and their students' mathematics self-efficacy?

It was hypothesised that teachers' theory-of-intelligence and that of their students would be positively correlated, particularly in the second half of the school year. Likewise, a teacher's self-efficacy for teaching mathematics was hypothesised to be correlated with their students' mathematics self-efficacy, especially later in the year. There was no evidence, however, to support either of these hypotheses. On the contrary, moderate *negative* correlations were found between the pre-intervention theory-of-intelligence of teachers in the Combined interventions group and their students' mathematics self-efficacy and achievement at each time point, suggesting that for this group, students' self-efficacy and achievement tended to be higher where their teacher's theory-of-intelligence was low, and student measures tended to be low when the teacher's theory-of-intelligence was high. For the two remaining groups, no patterns of significant correlations between teacher and student measures were identified. The associations between teachers' beliefs and those of their students identified in studies by Anderson et al. (1988) and Stipek et al (2001) were not evident in the present study.

The lack of correlation between teachers' self-efficacy for teaching mathematics and students' mathematics self-efficacy might be associated with the different specificity of the two self-efficacy measures used. Students' self-efficacy was operationalised as being related to specific problems, whereas teachers' self-efficacy was operationalised as domain-related. Furthermore, teachers were probably aware that their self-efficacy judgments would not be compared to their actual practice during the study, and this might have influenced how some teachers responded. As will be discussed shortly, the theory-of-intelligence questionnaire did not appear to provide meaningful information about students' and teachers' beliefs about the malleability of intelligence, because how they defined intelligence affected their malleability beliefs.

Theory-of-intelligence: Complexities and nuances

What is the nature of students' and teachers' theory-of-intelligence?

Together, the quantitative and qualitative data provided evidence that students' and teachers' theory-of-intelligence beliefs were not defined in absolute entity or incremental terms. Teachers' beliefs formed a continuum; students' beliefs about intelligence appeared to be influenced by the various ways in which they defined intelligence, and as such, were multi-dimensional. Definitions of intelligence expressed by students varied from simple to complex. More students gave a simple definition of intelligence as either knowledge, or as a relatively stable capacity, than gave a definition that included both (incremental) knowledge and a (stable) capacity component. In addition, students' beliefs varied in respect of the extent to which these components of intelligence can change.

Similarities between students' and teachers' definitions of intelligence were evident, although students tended to relate their descriptions of intelligence to their personal experience more than teachers, who were more likely to talk in terms of general principles. Students' ideas about what intelligence is and their beliefs about how much it can be changed were diverse, even among those who had similar theory-of-intelligence scores.

Students' definitions of intelligence fell into three broad categories: those who defined intelligence as a combination of a fairly stable capacity and a malleable knowledge component; those who defined it only as a stable capacity; and those who defined it only as a malleable knowledge component. How students defined intelligence appeared to be associated with how much they believed it can be changed. Students who described a combination of two components of intelligence tended to think they could increase their intelligence, but within limits due to the stable capacity component. Some of these students appeared to believe that they had a good amount of this capacity, and were keen to add to it by learning as much as possible. Students who believed intelligence is simply "How smart you are" – a stable capacity – were likely to perceive that they could change their intelligence only slightly. Still others seemed to think of intelligence as only the expandable knowledge component, and so were quite optimistic about being able to increase their intelligence.

Only tentative conclusions can be drawn by comparing ways in which students in the present study defined intelligence to those of similar age students in other

studies, due to variations in the coding and presentation of qualitative data. In the descriptions of the classifications Yussen and Kane (1985) used to analyse their data, their “Academic skills” category is very similar to the present study’s “How smart you are, being good at something”. Similarly, their “Knowledge” category is approximately parallel to the present study’s “Knowing, getting right answers”. Yussen and Kane identified a shift in definitions of intelligence of first to sixth-grade students, from younger students’ more frequent inclusion of social skills to older students’ greater emphasis on academic skills. Overall, findings from the present study appeared to contradict those of Yussen and Kane’s study. Defining intelligence with reference to academic skills was more frequent among Year 4 than Year 5 students in the present study – the opposite of Yussen and Kane’s finding. Yussen and Kane reported that knowledge was central at all grades, but in the present study, Year 5 students included knowledge-related comments more often than the Year 4 students did. There was very little mention of social skills across all students’ definitions of intelligence. Like Yussen and Kane (1985), Kurtz-Costes et al. (2005) found that younger children were more likely to include non-cognitive factors in their definitions of intelligence. In their study, Kurtz-Costes et al. did not differentiate knowledge from ability, instead including them both as “knowledge/achievement”. This makes it very difficult to draw any meaningful comparisons between their findings and those of the present study.

Cain and Dweck (1989) hypothesised that students believe intelligence is a combination of a fixed capacity and a knowledge component, and that entity theorists give greater weighting to the fixed capacity and incremental theorists, the knowledge aspect, in a dialectical relationship. The present study identified some students with a belief that intelligence comprises both a stable capacity and an expandable knowledge component, and some students who identified only one of these aspects, suggesting that Cain and Dweck’s hypothesis was simplistic. Students with high theory-of-intelligence scores were more likely than those with low scores to include knowledge or skill in their definition of intelligence. The former students did not emphasise intelligence as a fixed capacity any more than did the latter. Only a small proportion of the students indicated that they conceptualised intelligence as two-dimensional, probably because of their age.

It was not surprising that Year 5 students with high theory-of-intelligence scores tended to define intelligence as malleable knowledge, which may reflect these students’ perceptions about what is valued in the senior primary school years.

That the older students, more than the younger students, tended to believe their intelligence is expandable, might seem to be something of a contradiction. One might expect that as students get older, they develop more sophisticated conceptions of intelligence, and temper their optimism about increasing their intelligence. However, it is also likely that as students get older and start to understand possible limitations of their intelligence, they might also develop a clearer understanding of effective learning strategies they can use to maximise other aspects of their intelligence, which might account for this apparent optimism.

Theory-of-intelligence change over time

Do students' theory-of-intelligence beliefs change as they get older?

The hypothesis that the Control group's mean score for theory-of-intelligence would decrease over the three time points, consistent with a shift towards an entity theory-of-intelligence as students got older (Ablard & Mills, 1996; Kärkkäinen et al., 2008; Leonardi & Gialamas, 2002), was not supported by the data. In fact, the mean theory-of-intelligence score for all three groups increased on each occasion it was measured, suggesting a general trend in the opposite direction, towards an incremental theory, supporting the findings of Burke and Williams (2009) and Gonida et al. (2006), whose studies also involved primary students. From the quantitative data, it was not possible to determine whether this shift reflected an actual change in clearly-held beliefs or if this might have been related to the development of students' ability to understand *intelligence*, and a better understanding of what they were being asked in the questionnaire. At Time 3 in particular, there were several correlations between students' theory-of-intelligence and mathematics self-efficacy (see Table 6.3), which were not evident previously, and which might have been associated with a developing conceptualisation of intelligence as including both stable capacity and malleable knowledge components.

An important finding was that no students and few teachers were identified as having a strong entity theory-of-intelligence. Having an absolute entity theory implies a complete absence of belief that intelligence can change, but in previous research – particularly studies such as those conducted by Dweck et al. (1995) and Pepi et al. (2004), in which theory-of-intelligence scores were dichotomised – many of those who were labelled entity theorists might have been people with a weak incremental belief, rather than those who actually believe that intelligence is fixed.

Similarly, those who have been represented as incremental theorists are likely to have had a variety of views about the malleability of intelligence. Almost all student interviewees described varying degrees of incremental beliefs in their Time 1 interviews, so it was very difficult to identify change in students' beliefs at Time 2 from the qualitative data. It is possible that other researchers have encountered the same issue (without realising it), and that students with strong entity beliefs may have been equally scarce in previous studies. For example, using a 6-point Likert scale, the mean theory of intelligence score of 4.45 in Blackwell et al.'s (2007) study suggests that few of the 91 12 and 13-year-olds in their study showed a strong entity theory-of-intelligence. Where theory-of-intelligence scores seem to be concentrated in the upper half of the range, the spread of scores might represent more nuanced beliefs about how much intelligence can be increased than have been previously described.

Consideration was given to whether the lack of entity theorists might be a cultural difference in the beliefs of New Zealand students, compared to those of similar-age students in other countries where theory-of-intelligence has been measured. Results of two studies whose participants were similar ages and that used at least three of Dweck's (2000) items were compared to those of the present study. Gonida et al. (2006) conducted their study in Greece, and reported mean total scores, from a 6-point Likert scale, with 6 being a strong belief in the malleability of intelligence. For two groups of students, means were 4.53 (standard deviation 1.34) and 4.48 (standard deviation 1.22). Shih's (2007) study was conducted in Taiwan, and although no means or medians were reported, 69 of their 298 participants (around 23%) were identified as having an entity theory-of-intelligence. However, to be considered an entity theorist in Shih's study, participants had to score above the mean score for the three entity items and below the mean score for the incremental items. Although a similar approach was used in the present study to identify students to interview who had a range of beliefs about the malleability of intelligence, their interview responses demonstrated that none of them actually had a strong entity belief. Children's scores on theory-of-intelligence items do not seem to mean what researchers interpret them to mean. Whether there are indeed cultural differences in children's beliefs about the malleability of intelligence needs to be investigated using methods other than Dweck's theory-of-intelligence questionnaire.

Does an incremental theory foster <u>all</u> students' learning?

In the literature, an incremental theory is often espoused as an advantageous belief for everyone to have, because of its association – for students in some samples – with higher achievement, than was an entity belief. In the present study though, there was no evidence to support an association between a strongly incremental theory-of-intelligence and high achievement, or between a clear entity belief and low achievement. In fact, no students indicated a strong belief that intelligence cannot be changed, although a good number indicated a strongly incremental belief.

A belief that sat somewhere between extreme entity and incremental beliefs was suggested by some students' responses: one student in particular described thinking about different types of intelligence – a type that is essentially fixed, and one to which you can add. He was one of two quite articulate students who achieved high scores in mathematics, and who seemed to believe that intelligence is fairly stable but can be increased within limits. From their comments, both seemed to believe they were quite intelligent and that this was not going to increase substantially, and both had confident "can do" attitudes. For a slightly larger group of students who had a mixture of low and high theory-of-intelligence scores, the beginnings of this type of thinking were perhaps evident. Taking the mathematics achievement of some of the students in this group as an indicator of their intelligence, it seemed some of them were also very able.

There were no students in the present study who expressed a strong belief that they could not increase their intelligence. Consequently, there was no evidence relating to whether an entity theory-of-intelligence might have a negative effect, leading students to believe they are powerless to overcome their deficits, as Ziegler and Stoeger's (2010) research indicated. It seems probable that a student would feel more empowered to overcome their weaknesses, by a belief that they can increase their intelligence.

Dichotomising theory-of-intelligence, as either entity or incremental, belies the complexity of students' thinking about what intelligence is, and how much it can be changed. What previous studies of theory-of-intelligence have failed to identify is the varying degrees to which students believe different aspects of intelligence can be changed. None of the students in this study believed they could not increase their intelligence. Instead, students held a range of views that appeared to fall into

one of two broad categories: either that they had a limited potential to increase their intelligence, or that they could substantially increase their intelligence.

Perhaps, if any one of these beliefs about intelligence leads to learning for particular students, then they should be encouraged. However, perhaps even more helpful would be for teachers to ensure their students know that they expect all students to learn, and in fact, will press them to do so with appropriate support, on tasks with an inherent degree of challenge that is also appropriate. Teachers can help students to cope constructively with the difficult learning experiences they will then encounter by explicitly teaching them ways of coping in such situations. Whether students interpret teachers' expectations that they will learn as meaning they can change their intelligence, or as meaning that they can increase a component of their intelligence, may not actually be particularly important.

Mixing the quantitative and qualitative findings

Is there convergence between the quantitative and qualitative findings?

Quantitative and qualitative findings were compared to identify convergence and contradictions emerging from the data. Students' responses to interview questions about their mathematics self-efficacy largely confirmed the picture generated by their questionnaire responses, and shed some light on the factors on which they based these judgments. Students most typically judged their belief in their ability to solve a given problem according to whether they perceived the task as easy or difficult, and whether they believed they had the requisite mathematics knowledge or ability. Requiring students to make judgments about their ability to solve specific mathematics problems, as advocated by Bandura (1986, 2006), resulted in the instrument measuring what it was intended to, with evident precision. In the case of students' mathematics self-efficacy, the qualitative and quantitative findings converged.

In contrast, findings for theory-of-intelligence from the two datasets did not align in any meaningful way. The interviews provided insight into how poorly the questionnaire data for theory-of-intelligence for these students and teachers actually represented their beliefs about intelligence. Responding to theory-of-intelligence items seemed to involve an individual amalgamating their judgments of how much they believed the often-multiple components of what they defined as *intelligence* could change. Whatever the definition of *intelligence* students gave,

though, seemed to have little systematic association with their questionnaire scores. A student with a low score on the questionnaire, for instance, might have had a uni-dimensional perception of intelligence and believed it could be increased only slightly. Alternatively, they might have had a two-dimensional conceptualisation of intelligence and believed that although the knowledge component could be increased significantly, the capacity component was fairly stable. In light of this, the interpretation of students' questionnaire scores became quite problematic. For students of this age (from 7 years 7 months to 9 years 6 months old when the study began), the measure of theory-of-intelligence did not expose the complexity of their beliefs about intelligence, and in fact, yielded no meaningful information.

Students with more nuanced definitions of intelligence – perhaps closer to those expressed by teachers than by some of their peers – tended to have low scores for theory-of-intelligence, and some were very able mathematicians. This suggests that students with a more sophisticated understanding of intelligence and the factors that might influence it, might be more cautious about believing in its malleability. Perhaps rather than maintaining their naïve optimism that they can be successful at anything by expanding their accumulation of knowledge, students start to perceive limitations to their possibilities. The main limitation appears to be the realisation that intelligence is, at least partially, determined by genetic inheritance – a factor over which students have no control.

In Chapter 6, a number of statistically significant moderate correlations between mathematics self-efficacy and theory-of-intelligence – particularly involving Time 3 theory-of-intelligence – were unexplained. With evidence from the student interviews showing that the theory-of-intelligence instrument was an almost meaningless measure for students of this age, it is unclear what in fact was being measured by these items. The somewhat muddled factor loadings for these items are also suggestive of problems with the integrity of the instrument. It can therefore only be surmised that these correlations might be associated with older students tending to define intelligence as (malleable) knowledge, making it reasonable to think that as students got older, the relationship between their self-efficacy and (so-called) theory-of-intelligence might have strengthened.

Contribution to the research

The findings from this study contribute to the research into primary students' mathematics self-efficacy and theory-of-intelligence, and how these are associated with students' achievement.

First, the teacher-implemented strategies were shown to increase the mean mathematics self-efficacy and achievement of a group of students for whom these two measures were initially lower than those of students in a control group. Strategies used by teachers to help build their students' mathematics self-efficacy demonstrated that classroom-based interventions, delivered to students by their teachers, can be effective in changing students' beliefs and achievement, although little impact on teachers' beliefs was evident. The majority of intervention studies that have targeted students' self-efficacy and beliefs about intelligence have been experimental in nature and conducted entirely beyond the classroom by researchers (for example, Bandura & Schunk, 1981; Kinlaw & Kurtz-Costes, 2007; Mueller & Dweck, 1998; Ramdass & Zimmerman, 2008; Schunk, 1982, 1983a). In the present study, students were withdrawn from their classrooms for interview purposes only. I administered the mathematics self-efficacy, achievement, and theory-of-intelligence measures in-class, with teachers present. The actual interventions were the responsibility of teachers, meaning that teachers played a significant role in the study. While this meant I relinquished control over exactly what form the interventions took for students in different classes, it also meant that the interventions were tested by teachers in a variety of authentic teaching contexts.

Second, calibrating the mathematics self-efficacy and achievement instruments in this study to the same difficulty parameters gave a more rigorous measure of students' mathematics self-efficacy over time than has recently been used (see for example, Chen, 2006; Klassen, 2004; Ramdass & Zimmerman, 2008). Students' mathematics self-efficacy was measured with items that were referenced to specific mathematics problems that students were subsequently required to solve. These age-specific items were calibrated to the same difficulty scale, allowing more precise estimates of self-efficacy than in studies where the difficulty levels of problems were estimated by researchers (for example, Bandura & Schunk, 1981; Chen, 2006; Ramdass & Zimmerman, 2008; Relich et al., 1986). Furthermore, the same students' mathematics self-efficacy was measured on three occasions, over a 14-month period, extending the methods used in a 6-month study by Pajares and

Graham (1999) in which students' task-specific mathematics self-efficacy was assessed twice. Students' self-efficacy judgments were made in relation to two different teacher-designed exams, which were not calibrated to a difficulty scale.

Third, the findings of this study challenge some of the previous conceptualisations of beliefs about intelligence, and suggest that researchers might usefully ask some different questions about intelligence to help identify the apparent nuances in students' and teachers' beliefs. These questions might include: "What do you think intelligence is?" and "How much do you think [the components of intelligence that students describe] can be changed?" No students were identified as pure entity theorists, casting doubt on whether many students of similar ages in previous studies have actually held this belief. A small number of teachers, on the other hand, described clear entity beliefs about the malleability of intelligence, particularly pre-intervention. Students in the present study described intelligence as being either uni-dimensional or two-dimensional, but this was not systematically associated with students' questionnaire scores. Findings suggested that some students with high ability have more complex ideas about the nature of intelligence. Meaningful interpretation of students' scores on the theory-of-intelligence questionnaire was not possible. For students in the present study, their theory-of-intelligence scores were not generally helpful in predicting their mathematics self-efficacy or achievement. A theory-of-intelligence intervention had no significant effect on students' theory-of-intelligence, mathematics self-efficacy, or achievement. The findings raise questions about whether simply advocating an incremental theory-of-intelligence for all students – regardless of a their ability or beliefs about intelligence – will have the most positive effect on their achievement.

Limitations of the study

Practical considerations helped determine the scale of the study. The number of participating students and teachers was limited by there being a single researcher responsible for gathering and analysing data, and presenting professional development workshops. The length of time spent gathering data for this semi-longitudinal study was also dictated by feasibility. Within these limits, I aimed to maximise the quantity of data collected.

The ability to generalise findings to other contexts is limited by the sample size and also by the particular characteristics of the sample (for example, the schools were

all decile 7 to 10). Beliefs about intelligence and mathematics self-efficacy beliefs may differ according to students' ethnicity, social class, parents' education levels, and other factors. It was not the aim of this study to investigate these factors, and so the sample was not designed to support these explorations. Because the participants in this quasi-experimental research were in pre-determined class groups rather than being randomly assigned to treatment groups, the three groups of students and teachers were not exactly equivalent. Neither were the number of teachers participating in each school the same, with participation ranging from a single teacher at one school, to six at another school. These factors must therefore be considered when interpreting the study's findings.

I was aware that students with low mathematics self-efficacy might prefer to avoid participating in this study. For this reason, I visited each of the 24 classrooms to talk to students about their involvement, reassuring them that the focus was on their opinions and beliefs, and that to answer the questionnaire, they had simply to circle their answer. Students had an opportunity to ask questions, and as well as information and consent forms for their parents, students were given consent forms to show that their voices were valued. Nonetheless, it is likely that students with an aversion to mathematics-related school activities were more likely to decide not to participate than students who enjoyed mathematics.

Classroom observations of teachers in the intervention groups were not feasible, in addition to the considerable quantity of data already gathered for this study. The lack of in-class support and monitoring is likely to have contributed to the comparatively weak outcomes of the study. The explicit focus was on changing the beliefs of students, not those of teachers, although the latter may have influenced the former.

In order to investigate students' beliefs about learning in general, and beliefs about learning mathematics in particular, I chose to focus on students' mathematics self-efficacy and theory-of-intelligence. By deciding what to include, many other possible foci, such as the broader constructs of goal orientation and learning strategies, were excluded. There are many additional aspects of students' beliefs about learning that are also likely to play a role in how a student feels about learning mathematics, including the classroom culture, students' relationships with their teachers, and the influence of perceived expectations of parents, peers, and teachers.

Future directions

In future research, young students' ideas about the knowledge/skill and capacity/rate aspects of intelligence need to be made explicit, and then their beliefs about the malleability of each one, measured separately. There is much to be learnt about the nuances of students' beliefs about intelligence by seeking answers to questions such as, "What do you think intelligence is?" and "How much do you think [the components of intelligence that students describe] can be increased?", rather than seeking to determine "Do you (or do you not) think intelligence can be changed?"

Still more important, though, will be research that investigates the effects of teachers being clear with students about their expectation that students will succeed with learning that challenges them, and pressing them to do so, irrespective of teachers' and students' beliefs about intelligence. Alton-Lee (2003) emphasised the need for teachers to have high expectations for students' learning, supported by quality teaching in order to make a positive difference to students' achievement. More recently, it was stated in the *New Zealand Curriculum* that: "Students will be encouraged to value excellence, by aiming high and by persevering in the face of difficulties" (Ministry of Education, 2007, p. 10). Students need to be provided with opportunities to persevere with genuinely challenging learning. At times, this will inevitably involve them failing at a task, and this in itself is a valuable learning opportunity – one from which primary teachers tend to protect young students, unintentionally denying them the opportunity to learn appropriate ways to respond. Some of the coping strategies that teachers implemented in the present study as part of the mathematics self-efficacy intervention involved explicitly teaching students as young as 6 years old, appropriate ways to react when they encounter difficulty in their learning, such as applying greater effort, and persevering. The question of how New Zealand primary schools equip students to cope with difficulty and failure is an area for further investigation.

During their interviews, teachers and students suggested that strategy grouping for mathematics has a negative influence on the mathematics self-efficacy of students who were less able in mathematics. Whether this is in fact the case, and whether alternative organisational structures, such as co-operative groups or fluid groupings that focus on different content areas might have a more positive effect on the mathematics self-efficacy of less able students need further investigation. As Nicholls (1978) suggested, non-competitive arrangements seem to have the

potential to foster low achievers' engagement in learning, as well as engaging those who excel.

Whether there is a relationship between absences from school and students' beliefs in their abilities is another area for research. It seems reasonable that disruptions to learning caused by absences are likely to have negative effects on students' mathematics achievement and self-efficacy beliefs. In the present study, only four of the eight students in the Mathematics self-efficacy intervention group who were selected for interviews because they had low mathematics self-efficacy at Time 1 had complete datasets. More detailed information about students' absences could help to identify whether there is an inverse relationship between absences and mathematics self-efficacy, and would add to our knowledge of ways in which student absences can influence achievement.

Finally, measuring teachers' self-efficacy for teaching mathematics at the same level of specificity as students' mathematics self-efficacy would operationalise the construct in a manner that is more consistent with Bandura's (1986) definition of self-efficacy, and with recommendations for measuring self-efficacy (Bandura, 2006; Pajares, 1996b). This would require teachers making judgments about their ability to undertake specific teaching activities for particular students, which they would subsequently undertake. A teacher's self-efficacy could be compared with the achievement of the particular students, to give an indication of the difficulty of their specific teaching task. Measuring teachers' self-efficacy with a greater degree of precision might further illuminate the relationship between teachers' beliefs and students' achievement.

Concluding thoughts

Returning to my students with mathematics difficulties who were cited at the beginning of this thesis as motivating the research, some implications of the present work are apparent. Some of the strategies included by teachers in the mathematics self-efficacy intervention might have been helpful in encouraging these students to become more engaged in learning mathematics, which might in turn have supported an increase in their achievement. Although at the time I expressed to the students my confidence in their ability to master the concepts on which they worked, I was perhaps not insistent enough that they did actually master them. Had I pressed them more to work through the difficulties they encountered

until they succeeded, rather than pulling back when I could see them growing anxious or confused, it seems likely they would have developed stronger mathematics self-efficacy and higher achievement in this key learning area. I was reluctant to push these young students beyond work with which they were comfortable, and at the time, believed that encouraging them to enjoy mathematics work was also important. However, listening to the students and teachers in this study led me to think that perhaps an enjoyment of mathematics might be more surely developed for all students by teachers being insistent that students persevere until they succeed in achieving challenging goals. Supporting students with a suitable level of scaffolding for learning experiences that have an appropriate degree of challenge, and involving them in conversations about how they can improve their achievement (Alton-Lee, 2003; Hattie, 1999; Hattie & Timperley, 2007; Tunstall & Gipps, 1996a) are particular strategies that teachers can use to facilitate this, as teachers in the Mathematics self-efficacy intervention group demonstrated.

Clearly, addressing students' learning needs while at the same time building their mathematics self-efficacy poses a challenge for teachers, particularly in relation to students who find mathematics difficult. By encouraging students "to value excellence, by aiming high and by persevering in the face of difficulties" (Ministry of Education, 2007, p. 10), teachers can help build students' mathematics self-efficacy and achievement. The success of our endeavours in this area will be marked by students having "a 'can-do' attitude, and with students seeing themselves as capable learners" (p. 12), as did this student:

> I was always confident that I could solve things, and I just had to work it out, coz if I didn't believe that I could do it, then it would've been a lot harder, coz it's all about attitude. (Year 5 boy, high mathematics self-efficacy score)

To get to this point, teachers and students will together need to press on through challenging mathematics learning that may at times be uncomfortable, and indeed, may initially meet with failure. Teachers – as well as students – need to learn to persevere when their students encounter difficulty, and to make sure their students are equipped with strategies for responding constructively, rather than avoiding these potentially uncomfortable situations. That this can be effectively implemented during a mathematics lesson was demonstrated by one teacher who had earlier described her participation in the study as "galvanising" her resolve to deal more

pro-actively with challenging situations. The perseverance of teacher and students was apparent when the teacher described what unfolded as she and her students met with one such situation towards the end of the mathematics self-efficacy intervention:

> I was determined that they were going to do it before we'd finished, so that the whole kaupapa of default mode tears actually became, "I can think through that, and I have got strategies", and it was really effective. (Mathematics self-efficacy intervention group, teacher B)

It is this type of perseverance and determination that teachers need to cultivate, first in themselves, and then in their students, in order to raise students' mathematics self-efficacy and achievement.

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Appendices

Appendix A: Questionnaires

Student questionnaire

My ideas about learning

Practice example

Chocolate is good for you.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

The first set of questions is to find out your ideas about intelligence. Each sentence will be read to you, then you should circle the word (or words) to show how much you agree or disagree with it. There are no right or wrong answers. Please do your own work.

1. You have a certain amount of intelligence, and you really can't do much to change it.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

2. Your intelligence is something about you that you can't change very much.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

3. You can learn new things, but you can't really change your basic intelligence.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

4. No matter who you are, you can change your intelligence a lot.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

5. You can always greatly change how intelligent you are.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

6. No matter how much intelligence you have, you can always change it quite a bit.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

The second set of questions is about how confident you feel to solve maths problems. Look at each problem you are shown and think about how sure you feel that you could work out the answer, but <u>do not work out the answer!</u>
Circle the word (or words) that shows how much you agree or disagree that you can work out the correct answer.

7. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

8. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

9. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

10. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

11. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

12. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

13. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

14. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

15. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

16. I can work out the answer to this problem.

Strongly disagree	*Disagree*	*Mostly disagree*	*Mostly agree*	*Agree*	*Strongly agree*

My name is _____

I am in Year _____

I am in Room _____

Today's date is _____

Thank you very much for answering these questions!

Linda Bonne, PhD student, Victoria University of Wellington, student questionnaire

Teacher questionnaire

Beliefs about intelligence and teaching

Thank you for completing this questionnaire. The questionnaire has been designed to find out your ideas about intelligence, and some of your perceptions about teaching and learning in the area of mathematics. There are no right or wrong answers; I am interested only in your frank opinions. Please give your initial response to the questions, rather than deliberating over them; the entire questionnaire should take you a maximum of 15 minutes to complete.

Instructions: Using the scale below each statement, please indicate the extent to which you disagree or agree with each of the following statements by circling the appropriate response. Please circle one response only.

1. When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance in maths depends on his or her home environment.

Strongly disagree	**Disagree**	**Mostly disagree**	**Mostly agree**	**Agree**	**Strongly Agree**

2. I have enough training to deal with almost any learning problem in maths.

Strongly disagree	**Disagree**	**Mostly disagree**	**Mostly agree**	**Agree**	**Strongly Agree**

3. You can change even your basic intelligence level considerably.

Strongly disagree	**Disagree**	**Mostly disagree**	**Mostly agree**	**Agree**	**Strongly Agree**

4. No matter how much intelligence you have, you can always change it quite a bit.

Strongly disagree	**Disagree**	**Mostly disagree**	**Mostly agree**	**Agree**	**Strongly Agree**

5. When a student is having difficulty with the maths work I have given them, I am usually able to adjust it his/her level.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

6. If a student did not remember information I gave in a previous maths lesson, I would know how to increase his/her retention in the next lesson.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

7. When the maths marks of my students improve, it is usually because I found more effective approaches.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

8. To be honest, you can't really change how intelligent you are.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

9. When a student gets a better maths grade than he/she usually gets, it is usually because I found better ways of teaching that student.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

10. You can always substantially change how intelligent you are.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

11. You have a certain amount of intelligence, and you can't really do much to change it.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

12. If I really try hard in my maths teaching, I can get through to even the most difficult or unmotivated students.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

13. Even a teacher with good maths teaching abilities may not reach many students.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

14. Your intelligence is something about you that you can't change very much.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

15. The amount a student can learn in maths is primarily related to family background.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

16. No matter who you are, you can significantly change your intelligence level.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

17. When I really try, I can get through to most difficult students in maths.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

18. If a student masters a new maths concept quickly, this might be because I knew the necessary steps in teaching that concept.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

19. Teachers are not a very powerful influence on students' maths achievement when all factors are considered.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

20. You can learn new things, but you can't really change your basic intelligence.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

21. A teacher is very limited in what he/she can achieve because a student's home environment has a large influence on his/her maths achievement.

Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly Agree

Finally, a few details about yourself.

For how many complete years had you been teaching on January 1st 2010?

_____ years.

Please list your tertiary qualifications:

Do you have a degree with a mathematics major? Yes / No (*please circle one*)

Name …… Date: ……..

(Please print clearly)

Thank you for completing this questionnaire

Appendix B: Interview schedules

Student interview schedule, Time 1

Interview questions for student interviews
Term 2, 2010

Indicative interview script

Thanks for coming to talk to me. I really want to hear your ideas today, and I want to hear what you honestly think about a few different topics. At any time during the interview, you can tell me you don't want to do the interview, and that will be OK. If I ask a question you don't want to answer, then it's OK to just say, "Pass". I hope you'll try to answer all the questions.
I'm recording this interview so that I can listen to it again later, and write down some of the things you say that are interesting to me.

[Icebreaker] First of all, I'd like you to tell me about the thing you enjoy most about maths time in your classroom.
What's the thing you like most about maths time?
What's something about maths time that you don't enjoy so much?

Teacher-student feedback
Today I'm really interested in hearing what you have to say about what your teacher tells you about the work you do in maths and what they say about how your learning's going in maths. That's called feedback, when teachers talk to you about how you're going.

- First of all, can you tell me the sorts of things your teacher says to you when she/he thinks you've done well in maths?
- How does that make you feel?
- Does the feedback help you to learn? How?
- Are there any other sorts of feedback that you think would be useful to get when you do well in maths?
- What sorts of things does your teacher say when you're having trouble in maths?
- How does that make you feel?
- Does that help you to learn? How?
- Are there any other sorts of feedback that you think would be useful to get when you're having trouble in maths?
- What sort of feedback do you think is the most helpful to your learning?
- What sort of feedback do you think is the least helpful to your learning?

Mathematics self-efficacy
- In the questionnaire that you did with me last term, it looked as though you:
  - thought that you can solve the maths problems I showed you; or
  - thought you couldn't solve the maths problems I showed you.

  Is that right? Tell me why you thought this.
- What sort of feedback makes you like having a go at maths problems?
- Is there any feedback that might put you off having a go at maths work?

Theory of intelligence

- Tell me what you think intelligence is.

- What makes a person intelligent? How do they get to be intelligent?

- In the questionnaire that you did with me last term, it looked as though you:
    - believed you can change your intelligence a lot; or
    - believed you can change your intelligence a bit; or
    - believed you can't change your intelligence.

  Is that right? Tell me why you think this.

- Do you think your teacher thinks that kids can change their intelligence? How do you know?

- If you have trouble with your maths work, what do you to yourself in your mind?

- If one of your friends wasn't doing well with their maths work, what would you tell them they could do, to do better?

Thank you very much for sharing your ideas with me. The research that you have helped me with will help me to work out how teachers can help students' learning in maths.

Interview Questions for Students
Term 4, 2010

Indicative interview script
(Items marked with an asterisk were also asked in the Term 2 interview with the same students.)

Thanks for coming to talk to me again. I really want to hear your ideas today, and I want to hear what you honestly think about a few different topics. At any time during the interview, you can tell me you don't want to do the interview, and that will be OK. If I ask a question you don't want to answer, then it's OK to just say, "Pass". I hope you'll try to answer all the questions.

I'm recording this interview so that I can listen to it again later, and write down some of the things you say that are interesting to me.

[Icebreaker] First of all, I'd like you to tell me about the thing you enjoy most about maths time in your classroom.
What's the thing you like most about maths time?
What's the thing you enjoy least about maths time?

Mathematics self-efficacy

- In the questionnaire that you did with me last term, it looked as though you:
    - thought that you can solve the maths problems I showed you; or
    - thought you couldn't solve the maths problems I showed you.

  Is that right? Tell me why you thought this, if you can remember.*
  (If the trend in their maths self-efficacy responses is different to Term 1's, ask why this might have changed since then)

- What sorts of things does your teacher say to you about your maths work and your learning in maths? Does she tell you what you've done well and why/what you've done poorly and why? Does she describe your next learning steps and how to get there? Does she do this often? *(to identify whether teachers are using descriptive feedback in maths)*

- When your teacher chooses someone to show the class how they worked something out in maths, do you think she always chooses the smartest kids, or does she choose a mixture of students? Why do you think she does this? How does this make you feel? Why? *(to identify if teachers are using peer modelling, and the effects it might have on students.)*

Theory of intelligence

- Tell me what you think intelligence is.*

- In the questionnaire that you did with me last term, it looked as though you:
    - believe you can change your intelligence a lot;
    - believe you can't change your intelligence.

  Is that right? Tell me why you think this.*
  (If the trend in their theory of intelligence responses is different to Term 1's, ask why this might have changed since then)

- Do you think you can change your intelligence in maths? Why do you think that?

- Do you think your teacher thinks that kids can change their intelligence? How do you know?*
- If you have trouble with your maths work, what do you think to yourself?*
- If one of your friends wasn't doing well with their maths work, what would you tell them they could do, to do better?*

(The following items apply only to students in the theory of intelligence intervention group)

- Do you remember your teaching doing a couple of lessons about how the brain works? Tell me what you did in those lessons.
- What did you enjoy most in those lessons?
- What did you learn from those lessons?
- How has that helped your learning in maths?
- How do you **know** it's helped your learning?
- Do you think it's helped your learning in other areas? Can you tell me how you know?

Thank you very much for sharing your ideas with me. The research that you have helped me with will help me to work out how teachers can help students' learning in maths.

Interview Questions for Teachers
Term 2, 2010

Indicative interview script
(Items marked with an asterisk were also asked in the Term 2 interview with the same students.)

Introductions to the interviews
The overall purpose of this interview is to build a picture of your ideas about teacher-student feedback, your beliefs about learning in maths, and students' self-beliefs about their ability to succeed in learning mathematics. **There are no right or wrong responses to the questions I'm going to ask you.**

Beliefs about learning, with a focus on maths

- First of all, tell me what you think intelligence is.

- In your questionnaire, you indicated that you believe:
  - Intelligence can be changed; or
  - Intelligence can be changed to a degree; or
  - Intelligence cannot be changed much.

  Is that right? Tell me why you think this.

- How do you think this belief affects your own learning?

- How do you think this belief might affect your teaching?

- I'd like you to think about a particular child in your class who has trouble with maths. How might your belief about intelligence influence your interactions with that student?

- Now, thinking about a particular student who excels at maths, how might your beliefs affect your interactions with them?

Students' self-beliefs about their ability in mathematics

- How do you think students' self-beliefs about their ability in mathematics show themselves?

- If a student seems to think they're not very capable in maths, what do you do?

- Can you think of students who might have self-beliefs about their ability in maths that vary greatly from their actual ability in maths? (Please name, and describe relationship of self-beliefs to ability.)

- What factors do you think contribute to students' self-beliefs about their ability in mathematics?

- Which of those factors do you feel you can you influence, and how do you go about this?

Teacher-student feedback

- How do you give feedback to your students? (written, oral, body language) Could you give me an indication of what proportion of each type of feedback you typically use during maths?

Written:

Oral:

Body language:

- Thinking particularly about oral feedback, from your point of view, what is the purpose of teacher-student feedback?
- What do you consider when you're deciding what feedback to give a student?
- In your experience, what have you noticed about how students respond to various forms of feedback (written, oral, body language), and different feedback content (praise, next steps, identifying wrong answers)?
- In what ways does a student's reaction influence the feedback you choose to give them?
- If I asked your students to tell me the most common feedback phrase you use, what do you think they would say?
- What professional learning and development have you engaged in over the last five years or so that included a focus on teacher-student feedback? What was the impact of this on your practice?
- Do you know of any ways of categorising teacher-student feedback and how these might be useful to teachers?
- What feedback do you remember receiving from teachers when you were at school?
- Can you describe the effect/s that had on you?
- How might your own experience of feedback have affected the feedback you now give students?

Thank you!

Interview Questions for Teachers
Term 4, 2010

Indicative interview script
(Items marked with an asterisk were also asked in the Term 2 interview with the same students.)

Introduction
The purpose of this interview is to explore how your ideas about learning in maths may have changed since the start of the year, and to identify the effect on you and your students of the after-school workshops. **There are no right or wrong responses to the questions I'm going to ask you.**

Theory of intelligence, with a focus on maths
(The first items are for teachers in both intervention groups.)

- Tell me what you think intelligence is.*
- In your questionnaire responses, you indicated that you believe*:
    - Intelligence can be changed; or
    - Intelligence cannot be changed much.

  Is that right? Tell me why you think this.
- *[Where this seems to have changed since Term 1:]* It looks as though you're feeling more/less sure that intelligence can be changed than you were in Term 1. Why might this be?
- How do you think this belief might affect your teaching?* How might this belief affect your students' learning?

*(The following theory of intelligence items are for teachers in the theory of intelligence intervention group **only**.)*

- Thinking about the two brain lessons you were asked to teach your class, can you tell me approximately how much class time was spent on this? Were the lessons taught very soon after the workshop we did? (i.e. within a week)
- What was the response from your students? Which aspect of the lessons seemed to have the greatest impact on students?
- Do you have any reason to think these lessons had an impact on students' beliefs about intelligence? What evidence do you have to support this?
- In what ways might your own beliefs about intelligence have changed since the start of this research? Why?
- How has your knowledge of theories of intelligence affected your teaching?
- Are you aware of any changes in the way you interact with your students, as a result of the theory of intelligence workshop?
- Have you discussed theories of intelligence with colleagues in your school? Was this during a syndicate/staff meeting, or more informally? How did this affect your beliefs about the malleability of intelligence?
- Have you talked about this with people beyond school? (Probe for details.) How did this affect your beliefs about the malleability of intelligence?
- Do you think it's important that teachers have some knowledge of theories of intelligence? Why?
- What value, if any, do you see in students completing theory of intelligence self-assessments? How might you use this information?

Students' mathematics self-efficacy

- Thinking about the workshops we did that looked at strategies to build students' maths self-efficacy, how has your practice changed as a result?
- How have you observed these changes have affected students' maths self-efficacy? What evidence do you have?
- How have these changes affected students' maths achievement? What evidence do you have?
- What connection, if any, have you noticed between students' mathematics self-efficacy and their achievement in mathematics? Please give specific examples.
- What do you think was the most important thing you did that helped build students' maths self-efficacy? *[Refer teacher to the list of 8 strategies presented in the SE workshop.]* Why was this so important?
- Do you think the strategies you've been focussing on to develop students' maths self-efficacy have had any spill-over into other learning areas?
- During Term 3, were there any circumstances or events in your school or your classroom that would impact on students, e.g. school production, having a student teacher?
- Have you discussed maths self-efficacy with colleagues in your school? Was this during a syndicate/staff meeting, or more informally? How did this affect your beliefs about students' maths self-efficacy?
- Have you talked about this with people beyond school? (Probe for details.) How did this affect your beliefs about students' maths self-efficacy?
- What value, if any, do you see in students completing maths self-efficacy self-assessments? How could you use this information?

The next few questions relate to teacher-student feedback, as a potential strategy for building students' maths self-efficacy.

- In what ways do you think you've changed the feedback you give to your students during maths, as a result of your participation in this research? *[Offer teacher Tunstall & Gipps typology, which was introduced at the 2nd maths self-efficacy workshop, to support their response to this, and other items in this section.]*
- What effects have you noticed this has had on your students? Do you have evidence to support your observations?
- How have your students responded to any changes you've been making to the feedback you give them?
- What effect do you think it might be having on students' learning in maths? What evidence do you have?
- What do you consider when you're deciding what feedback to give a student?* *[Probe for category of feedback (Tunstall & Gipps), effects on students' maths self-efficacy, what was the learning intention.]*
- What issues have arisen for you and your students, relating to feedback? *[e.g., between students; emotional responses; competition to get feedback; child-centred pedagogy: non-competitive/protecting students from failure/culture of niceness.]*

Coming back to thinking more broadly about maths self-efficacy:

- What factors do you think contribute to students' maths self-efficacy?*
- Which of those factors can you influence, and how do you go about this?*
- Do you think the physical classroom environment influences students' maths self-efficacy?
- What effect if any, do you think strategy grouping might have on students' maths self-efficacy?

Thinking about your participation over the year in this study:

- Do you think it's important for teachers to have some knowledge about maths self-efficacy? Why?
- What have been the challenges, if any, in implementing the strategies we've discussed at workshops?
- How might the start of the next school year be different for students in your class, to the way it was at the start of this year? What sorts of things might you want to establish with your students from the beginning of your year together?

Thank you!

Appendix C: Factor loadings on questionnaires

Factor loadings for student and teacher pilot questionnaires

Table C.1: Loadings on the first three factors, based on a principal components analysis of theory-of-intelligence items (1 to 12) and mathematics self-efficacy items (13 to 22) in the pilot of the student questionnaire for Year 4 and 5. Items are ordered by weighting on Factor 1. Note: Factor loadings < .2 are not shown.

		Factor 1	Factor 2	Factor 3
Item	Variance	24%	10%	9%
	Theory-of-intelligence items			
11	When something I am studying is difficult, I try harder.	0.20	0.24	0.34
5	You can always greatly change how intelligent you are.	0.20		0.70
3	You can learn new things, but you can't really change your basic intelligence.		0.64	-0.22
10	To tell the truth, when I work hard at my schoolwork, it makes me feel like I'm not very smart.			0.36
2	Your intelligence is something about you that you can't change very much.		0.77	
9	The harder you work at something, the better you'll be at it.			
1	You have a certain amount of intelligence, and you really can't do much to change it.		0.77	
6	No matter how much intelligence you have, you can always change it quite a bit.		-0.30	0.61
4	No matter who you are, you can change your intelligence a lot.		-0.23	0.80
12	When I fail to understand something, I become discouraged to the point of wanting to give up.			
8	It is much more important for me to learn things at school than it is to get the best marks.		0.27	
7	Even geniuses work hard for their discoveries.			0.30
	Mathematics self-efficacy items			
20	If 3 x 12 = 36, then 6 x 12 will equal: A. 2 x 36; B. 3 x 36; C. 6 + 36; D. 12 + 36	0.76		
16	At the pet show there were 38 dogs, 46 cats, and 29 rabbits. How many animals were there altogether?	0.75		
22	Ligi has drawn arrows on the number line to help solve 121 - □ = 57. What number should go in the □ to make the sentence true?	0.74		
18	Ants have 6 legs. How many legs in total would there be on 43 ants?	0.73		
21	25 + □ = 55. What number should go in the □ to make the sentence true?	0.66		
14	In a game these counters are used for money. How much would this group of counters be worth altogether?	0.66		0.29
19	What fraction of this group of circles is shaded?	0.66		

		Factor 1	Factor 2	Factor 3
Item	Variance	24%	10%	9%
13	What does the 7 stand for in 756?	0.60		-0.22
15	How many $10 notes will it take to buy this bike?	0.57		0.21
17	This tree has 8 apples on it. If the wind blows ¼ of them onto the ground, how many apples are left on the tree?	0.57		

Table C.2: Loadings on the first three factors, based on a principal components analysis of all original items in the pilot of the teacher questionnaire. Items are ordered by weighting on Factor 1. Note: Factor loadings < .2 are not shown.

		Factor 1	Factor 2	Factor 3
Item	Variance	20%	18%	11%
	Theory-of-intelligence items			
7	No matter how much intelligence you have, you can always change it quite a bit.	0.85		
8	You can change even your basic intelligence level considerably.	0.78	-0.25	
5	You can always substantially change how intelligent you are.	0.75		
3	No matter who you are, you can significantly change your intelligence level.	0.72	-0.21	
4	To be honest, you can't really change how intelligent you are.	-0.71	0.41	
6	You can learn new things, but you can't really change your basic intelligence.	-0.67	0.36	0.21
1	You have a certain amount of intelligence, and you can't really do much to change it.	-0.62	0.44	0.20
2	Your intelligence is something about you that you can't change very much.	-0.61	0.43	0.28
	Self-efficacy for teaching mathematics items			
13	When a student gets a better maths grade than he/she usually gets, it is usually because I found better ways of teaching that student.	0.42	0.55	
22	If I really try hard in my maths teaching, I can get through to even the most difficult or unmotivated students.	0.35	0.64	
9	When a student does better than usual in maths, many times it is because I exert a little extra effort.	0.35	0.20	0.36
21	If one of my students couldn't do the maths work they were given, I would be able to accurately assess whether the work was at the correct level of difficulty.	0.33	0.39	
12	When a student is having difficulty with the maths work I have given them, I am usually able to adjust it his/her level.	0.32	0.44	0.27
14	When I really try, I can get through to most difficult students in maths.	0.28	0.55	
25	My teacher training programme and/or experience has given me the necessary skills to be an effective teacher of maths.	0.25	0.26	0.31
18	If a student masters a new maths concept quickly, this might be because I knew the necessary steps in teaching that concept.	0.23	0.67	
11	I have enough training to deal with almost any learning problem in maths.	0.20	0.61	
19	If a student did not remember information I gave in a previous maths lesson, I would know how to		0.52	

		Factor 1	Factor 2	Factor 3
	increase his/her retention in the next lesson.			
24	Some students need to be placed in slower maths groups so they are not subjected to unrealistic expectations.			0.27
16	Teachers are not a very powerful influence on students' maths achievement when all factors are considered.		-0.44	0.38
15	A teacher is very limited in what he/she can achieve because a student's home environment has a large influence on his/her maths achievement.		-0.42	0.75
17	When the maths marks of my students improve, it is usually because I found more effective approaches.		0.67	0.25
23	When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance in maths depends on his or her home environment.		-0.30	0.82
20	Even a teacher with good maths teaching abilities may not reach many students.		-0.44	0.44
10	The amount a student can learn in maths is primarily related to family background.			0.64

Appendix D: Theory-of-intelligence intervention lessons

Mindset (Theory-of-Intelligence) Lessons

It is intended that both lessons might be spread over two sessions each.
Please note: The model is to be handled only by teachers, and can be carefully taken apart to illustrate different parts of the brain. (Supporting resources in the form of posters 1A to 2D were provided for teachers.)

Lesson 1: *Brain facts*

Learning intention:
- To understand key anatomy and functions of the brain.

Success criteria:
- Show where the cerebrum is on a picture/model of the brain;
- State what the cerebrum does.

Suggested learning progression:
- Show students model of brain and/or posters (1A & 1B). Use these to highlight:
    - Cerebrum [si-ree-brim] – the largest part of the brain, has two halves/hemispheres: right/left (model is of left hemisphere only). Right half of brain controls left side of body, and vice versa. The cerebrum is responsible for thinking (*and is the part of the brain that we're aiming to strengthen through exercise*);
    - Cerebellum [sarah-bellim] – controls automatic body movements (balance, co-ordination);
    - Brain stem – connecting the brain to spinal cord, controlling body functions (breathing, digestion);
    - Thalamus [thal-amiss] – receives and re-directs signals from nerves.

The following parts of the brain can be introduced too, but are not the main focus.
    - Hippocampus – memories;
    - Hypothalamus – senses hunger, tiredness, controls body temp;
    - Corpus callosum – thick band of nerve fibres that connects the 2 halves/hemispheres.

- "Fist for a brain" (1C) – activity to give students an idea of the size of their brain. Because students' hand sizes – and therefore their "brain" sizes – will vary, stress that it's not the size of the brain that makes you smart as much as how much you exercise your brain.
- "Amazing facts about the brain" (1D) to wrap up.

Lesson 2: *Making ourselves smarter*

Learning intention:

- To understand what happens to your brain when you practise and learn new things

Success criteria:

- To be able to explain that the brain is like a muscle that gets stronger with exercise;
- To identify making mistakes and practice as important factors in becoming smarter.

Suggested learning progression:

- Read "Why shouldn't I watch TV all day?" (2A) to students. Summarise by saying that when we learn something new, we build connections (synapses) between neurons in our brain.
- Chinese whispers activity to demonstrate how messages are sent along a series of neurons. Alternatively, have students stand in a line, first person taps the shoulder of the second person, then second taps third, and so on.
- Show "Nerve cells" (2B) to highlight the role of neurons and the connections between them.
- Read *How can I help my brain get smarter?* (2C) to students to highlight how the brain is like a muscle that they can strengthen through exercise and practice.
- What happens when you learn a new skill?
    - Have students share in groups a time they were learning a new skill (sport/music/ballet, etc are good examples; times tables/basic facts are maths examples that apply here), and the practice that was involved to become good at whatever it was.
    - Were they clever at it straightaway? ("Everything is hard before it is easy.") Reinforce the importance of making mistakes.
    - What effects would practising have on their brain? (strengthening existing connections, and building connections, between neurons in your brain).
    - If your brain can get stronger with practice, how can that help you?

"How can I get smarter?" (2D) – to summarise key points, and act as a reference.

Appendix E: Information sheets, consent forms, confidentiality agreements

Student information sheet

Research Title: *An investigation of the relationships between students' mindsets, mathematics self-efficacy beliefs, and mathematics achievement*

Information Sheet for Students

I am doing research into how teachers might be able to help students do even better in mathematics, and I want to ask you to be part of this research. Your teacher has agreed to take part.

Here is what you would do, if you agree to help me. In Term 1, I will be asking teachers and students to tell me their ideas about learning mathematics by answering some written questions. I might also ask if I can interview you, and I would make a recording of this to listen to after the interview. In Term 4, I will ask you for your ideas again, and will interview the same students again. I would also like to come back to ask you for your ideas for a third time, in Term 2 next year.

I have asked your principal if I can have the results of your mathematics PAT, which you usually do in Term 1. I will also need you to do a mathematics PAT in Term 4, and in Term 2 next year, to see how you are going with your mathematics learning.

I am doing this research so that teachers can find out really good ways of teaching mathematics. I will write about what I find out, and talk to people about it, so that other teachers can hear about it. When I tell other people about this research, I won't use your real name.

The ideas you tell me about are confidential. That means that no-one except my teachers (called 'supervisors') and I will know which ideas came from each person.

I would really like it if you could help me with my research, but you can say no if you don't want to. If you agree to be part of the project now, you can stop being part of it any time by telling your teacher, your parents, or me that you want to stop. Please talk with an adult about this, then fill out the consent form and give it to your teacher.

If you have any questions, please ask your teacher or me, or you can contact my supervisors.

P.T.O.

Thank you very much,

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TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Research Title: *An investigation of the relationships between students' implicit theories of intelligence, mathematics self-efficacy beliefs, and mathematics achievement*

Student's Consent to Participate in Research

I have had this research project explained to me by an adult. I know that being part of the research means I agree to:

(Please tick each box)

☐ write my answers to questions asked by the researcher at the start and end of this year, and half-way through next year.

☐ maybe being interviewed twice by Linda (the researcher), and the interview being recorded.

I understand that:

☐ Linda and my teacher will know the answers that I gave, and that my parents can talk to Linda or my teacher about my answers.

☐ it's OK for me to say no to being part of the research.

☐ I can stop being part of the research after it begins, if I want to, by telling my teacher or Linda that I no longer want to do it.

☐ my ideas will be used for the research and to help other teachers know how to help students learn maths well.

☐ Linda will keep my answers and audio recordings of interviews until five years after the research has finished, because she might want to look at, or listen to, them again. After five years, Linda will get rid of them.

☐ when Linda writes about things I say, she will not use my real name.

My name is ..... I am in Room .....

at ..... School.

(please tick only one box)

☐ I agree to be part of this research,

or

☐ I don't want to be part of this research

My signature: _____ The date is: _____

Research Title: *An investigation of the relationships between students' mindsets, mathematics self-efficacy, and mathematics achievement*

Information Sheet for Parents & Guardians

This research is being undertaken as part of my doctoral studies at Victoria University of Wellington. The overall aim of the study is to investigate whether two interventions that target students' beliefs about learning are associated with improvements in their mathematics achievement. Participation in this research may help to identify ways to raise students' mathematics achievement. This research has been assessed and approved by Victoria University of Wellington's Faculty of Education Ethics Committee.

I have chosen to conduct this research with Year 4 and 5 students and their teachers because students of this age are clarifying their beliefs about school and learning. It may prove important to work with these relatively young students to identify beliefs they may have about their learning that have the potential to impede their progress.

A group of teachers from your child's school have agreed to participate in the research, and will be randomly assigned to one of three groups taking part. In order to keep the focus of each of the three groups totally separate, it is not possible to describe the exact focus of each one.

Your child's involvement in the research will help identify ways to promote learning in mathematics. During Term 1, students will complete a self-assessment of their beliefs about learning, as part of their classroom programme. This will take less than half an hour, and will be repeated in Term 4, and again in Term 2 of 2011. A small number of students will be asked to participate in interviews with the researcher that will take place at school, during normal school hours. This interview will take no longer than thirty minutes, and will be repeated in Term 4 with the same students. With your consent, your child may be selected to participate in the interview, of which an audio recording will be made.

Students' mathematics PAT results from Term 1 will also inform this research. This snapshot of students' mathematics understanding will be repeated in Term 4, and in Term 2 of 2011.

The results of all assessments will be confidential the researcher and supervisors.

Your child, their teacher, and their school will not be identified in any reports or publications relating to this research. Once the research is completed, a hard copy of a summary will be available to you on request.

I am happy for you to contact me if you or your child has any questions. My supervisors contact details are also provided.

Sincerely,

Linda Bonne
Victoria University of Wellington
linda.bonne@vuw.ac.nz
Ph: (04) 4635233 Ext: 9852

Supervisors:
Dr Joanna Higgins
School of Education Policy & Implementation
Faculty of Education
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Parent consent form

Research Title: *An investigation of the relationships between students' mindsets, mathematics self-efficacy beliefs, and mathematics achievement*

Consent for Students to Participate in Research: Students' Parents & Guardians

(Please tick each box)

☐ I have been given and have understood an explanation of this research project. I have been provided with the researcher's contact details so that I can ask questions and have them answered to my satisfaction.

☐ I understand that my child will complete assessment tasks related to the research, as part of their classroom programme from the start of 2010 until mid-2011 (a total of six assessments).

☐ I agree to my child's possible inclusion in a one-to-one interview with the researcher. They would be interviewed during school time, at school. The interview would be recorded. The researcher may want to show play excerpts of audio recordings to meetings of teachers, for discussion purposes. Teachers at these meetings would have undertaken to keep the content of meetings confidential. The researcher will also check with your child's teacher before excerpts are played at meetings.

☐ The published results will not use my child's name, or identify their teacher or school, and no opinions will be attributed to my child in any way that will identify him or her.

☐ I understand that my child may withdraw from this research at any time by telling their teacher or the researcher that they do not wish to participate, without having to give reasons and without penalty of any sort.

I agree / do not agree *(please delete one)* to my child, _____

in Room _____ at _____ [name of school]

taking part in this research.

Name of parent/guardian: _____ (please print clearly)

Signed: _____ Date: _____

P.T.O.

☐ I would like to receive a summary of the results of this research when it is completed.

Postal or email address to which a summary of the research should be sent:

Research Title: *An investigation of the relationships between students' mindsets, mathematics self-efficacy, and mathematics achievement*

Information Sheet for Teachers and Principals

This research is being undertaken as part of my doctoral studies at Victoria University of Wellington. The overall aim of the study is to investigate whether two interventions that target students' beliefs about learning are associated with improvements in their mathematics achievement. Participation in this research may help to identify ways to raise students' achievement. This research has been assessed and approved by Victoria University of Wellington's Faculty of Education Ethics Committee.

I have chosen to conduct this research with Year 4 and 5 students and their teachers. Students in this age group are developing clearer beliefs about school and learning, and the research literature indicates that it may be important to work with relatively young children to identify beliefs they may have about learning that may impede their progress.

Where at least three teachers of Year 4 and 5 students at a school agree to participate, each school will be randomly assigned to one of three groups:

1. A control group who will receive no intervention. This group will be important because it provides benchmark information against which to measure progress of students in the other two groups;
2. A group who will be involved in Intervention One;
3. A group who will be involved in Interventions One and Two.

In order to keep the focus of each of the three groups totally separate, it is not possible to describe the exact focus of each one.

Teachers who agree to participate will be interviewed by me at the start and end of the school year. These one-to-one interviews will be no longer than one hour, and release time will be provided for this purpose. Information from interviews will be confidential to me and my supervisors, and teachers will have an opportunity to check that their ideas are fairly represented in transcripts of interviews.

Then from April to October teachers allocated to Groups 2 and 3 will attend one after-school meeting per term of up to two hours with me and the other teachers in their group, to plan the implementation of an intervention, and review progress. (Group 1, the control group, will meet in Term 1 and again early in 2011 to hear a summary of the research findings.)

P.T.O.

As part of the classroom programme, students in participating teachers' classes will complete two written assessments at the start and end of 2010, and again in Term 2 of 2011. These assessments are a mathematics PAT and a self-assessment of students' beliefs about learning in mathematics. Students' 2011 teachers will also be asked to complete a self-assessment of their beliefs about learning in mathematics. The data collected in 2011 will be important as they will give an indication of the enduring effects of the interventions. I will be responsible for organising the assessments in consultation with teachers.

Once the research is completed, participating teachers and principals will have an opportunity to attend a meeting where a summary of the findings will be presented. A hard copy of a summary will also be available to you on request. No teachers, students or schools will be identified in any publication relating to this research; pseudonyms will be used.

I am happy for you to contact me if you have any questions. My supervisors contact details are also provided.

Sincerely

Linda Bonne
Victoria University of Wellington
Phone: 04 4635233 Ext: 9852
Email: linda.bonne@vuw.ac.nz

Supervisors:
Dr Joanna Higgins
School of Education Policy & Implementation
Faculty of Education
Victoria University of Wellington
Phone: 04 463 9576
Email: joanna.higgins@vuw.ac.nz

Dr Michael Johnston
Senior Statistical Analyst
New Zealand Qualifications Authority
Phone: 04 463 3164
Email: michael.johnston@nzqa.govt.nz

Teacher consent form

Research Title: *An investigation of the relationships between students' mindsets, mathematics self-efficacy beliefs, and mathematics achievement*

Teacher's Consent to Participate in Research

(Please tick each box)

☐ I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered to my satisfaction.

☐ I understand that I have been invited to participate from February to November 2010, and that during 2011 I will also have the opportunity to attend a feedback meeting and three workshops designed to help teachers implement what is learned from the research.

☐ I understand that, should I agree to participate, I will be randomly assigned, along with other Year 4 and 5 teachers at my school, to one of three groups. (Teachers from my school will be included in the research only if at least three teachers consent to participate.)

☐ I agree to maintain confidentiality within the group to which I am assigned.

☐ I agree to complete a written assessment of my self-beliefs about teaching and learning, in Terms 1 and 4 of 2010. This should take no longer than 20 minutes.

☐ I agree to be interviewed by the researcher during school hours (release time will be provided) in Terms 1 and 4 of 2010. Interviews will not exceed one hour.

☐ I understand that, depending which group our school's teachers are assigned to, I may be required to attend up to two after-school workshops of up to two hours each term during 2010, and to apply the ideas discussed at the workshops to my teaching practice, to the best of my ability.

☐ I understand that any information I provide during interviews will be kept confidential to the researcher and her supervisors.

☐ I understand that the researcher may want to show video excerpts of interviews with small groups of my students at meetings with my assigned group of teachers, for discussion purposes. Prior to such meetings the researcher will discuss with me which excerpts are to be presented and why, and I will have the right to veto their being shown.

☐ I understand that the researcher will provide full instructions for a written self-assessment that students will complete in Terms 1 and 4 of 2010. The researcher will also require students' mathematics PAT scores in Terms 1 and 4, and will be responsible for organising this in consultation with me. All students' results will be shared with me.

☐ I understand that I may withdraw from this project at any time, without having to give reasons and without penalty of any sort.

☐ The published results will not use my name, or identify my school or any of my students, and no opinions will be attributed to me in any way that will identify me.

(Please tick only one box)
☐ I agree to take part in this research.

Or

☐ I do not wish to take part in this research.

Signed: _____

Name of participant: _____
(please print clearly)

Date: _____

☐ I would like to receive a summary of the results of this research when it is completed.

Postal or email address to which a summary of the research should be sent:

Research Title: *An investigation of the relationships between students' mindsets, mathematics self-efficacy beliefs, and mathematics achievement*

Principal's Consent for Teachers to Participate in Research

(Please tick each box)

☐ I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered to my satisfaction.

☐ I understand that all teachers of Year 4 and 5 students at the school will be invited to participate in the research. This will be done at a meeting arranged by the researcher and myself, where the researcher will give an overview of what the study will involve, and where the teachers and I will have opportunities to ask questions. Teachers will each be given an Information Sheet about the research, as well as a Consent Form. They may choose to complete the consent form at the end of the meeting, or within three days thereafter. Teachers' participation is purely voluntary and there will be no penalty for any teacher who chooses not to participate, or who withdraws part-way through the study.

☐ I understand that our school can be involved in the research only if at least three teachers consent to participate. This is because it will be important for teachers to have collegial support if they are allocated to group that includes a professional development component.

☐ I understand that participating Year 4 and 5 teachers from our school will then be randomly assigned as a group to one of three larger groups.

☐ I understand that teachers' involvement in the study will include being responsible for completing written assessments of their self-beliefs about teaching and learning at the start and end of 2010. Depending on which of the three groups the school's teachers are assigned to, teachers' involvement may also include attending after-school workshops once a term during 2010, for up to two hours per workshop, and applying the ideas discussed to their teaching practice, to the best of their abilities.

☐ I understand that students' participation will involve completing written assessments at the start and end of 2010, as well as follow-up assessments in Term 2 of 2011. These assessments are the *PAT: Mathematics* and a written assessment of their self-beliefs about learning. A small number of students will also be involved in small group interviews with the researcher in the first and last terms of the 2010 school year.

P.T.O.

☐ I agree to our school and our Year 4 and 5 teachers and students participating in this research, with their informed consent.

Or

☐ I do not wish our school to participate in this study.

Signed: _____

Principal's name: (please print) _____

School: _____

Date: _____

☐ I would like to receive a summary of the findings once the research is completed.

Postal or email address to which a summary should be sent:

Project Title: An investigation into the relationship between students' theories of intelligence, mathematics self-efficacy, and mathematics achievement

Transcriber Confidentiality Agreement

I agree to keep the contents of the interview material confidential. This means not disclosing any information to any other person except the named researcher for this project.

While I am transcribing audio files, I will keep any hard copies of the data in a locked cupboard, and keep electronic data password-protected. I will send transcripts to the researcher when the transcribing is complete, and then delete all electronic files.

Name: .....

Signature: .....

Date: .....

Appendix F: Missing data information for students

Table F.1: Missing data frequencies

Frequencies of missing data for the student questionnaire and achievement test for Times 1, 2, and 3 for Year 4 and 5 students by treatment group, with percentage of students in brackets. All students completed the Time 1 questionnaire to be included in the study. Treatment groups are: Control group (Control); Mathematics self-efficacy intervention group (Maths self-efficacy); and Combined mathematics self-efficacy and theory-of-intelligence group (Combined).

Treatment group	Time 2 questionnaire	Time 3 questionnaire	Time 1 achievement	Time 2 achievement	Time 3 achievement
Control (n = 58)	5 (*9%*)	1 (*2%*)	0 (*0%*)	1 (*2%*)	3 (*5%*)
Maths self-efficacy (n = 71)	11 (*15%*)	10 (*14%*)	1 (*1%*)	1 (*1%*)	11 (*15%*)
Combined (n = 87)	12 (*14%*)	12 (*14%*)	2 (*1%*)	7 (*8%*)	8 (*9%*)

Table F.2: Individual students' missing data

Individual Year 4 and 5 students who had missing quantitative data by number and percentage of their group, by treatment group: Control group (Control); Mathematics self-efficacy intervention group (Maths self-efficacy); and Combined mathematics self-efficacy and theory-of-intelligence interventions group (Combined).

Treatment group	Number of students with missing data	Percentage of treatment group for whom some data were missing
Control	8	14
Maths self-efficacy	18	25
Combined	26	30