Mindset and Mathematics in an All-Girls Secondary School

A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy at Charles Sturt University by Maureen Moore BA Dip Ed MA MEd

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Certificate of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Charles Sturt University or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by colleagues with whom I have worked at Charles Sturt University or elsewhere during my candidature is fully acknowledged.

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Signature:                                                                                                 Date:

Maureen Moore
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Abstract

Implicit theories of intelligence or mindset is vital in understanding adolescent cognition and motivation. Dweck (2000, 2006), categorised people as having one of two types of mindset: fixed (entity theorists) and growth (incremental theorists). Both mindsets have implications for how individuals behave in academic contexts. There is considerable evidence of declining participation in mathematics in Australia (Leder & Taylor, 2010; Murray, 2011). This decline is a matter for significant concern, for reasons related to both national economic growth and social equity. The mindset theoretical framework offers a valuable way of understanding students’ attitudes towards and participation in mathematics. This thesis combines three major fields of study; mindset, mathematics and gender.

The principal aims of this study were to investigate the implicit theories of intelligence (mindset) held by female students from Years 7 to 12 in a single-sex comprehensive secondary school, and explore the relationship between their mindset, participation in mathematics and their self-reported learning behaviours. Five research questions were investigated using a mixed method approach including a questionnaire and semi-structured interviews as data gathering tools.

Quantitative analysis of the school sample mindset data revealed that over 66% of students supported the statements “their intelligence could be developed or grown”. The student interviews however revealed a far more complex, and at times contradictory picture. Overlaying students’ mindsets were other variations in student beliefs. The very popular student belief that intelligence was inherited (innate) and could be further developed by learning and life experiences, had the potential for significant learning consequences. Secondly, the students who set a ceiling or cap on their intelligence by assuming they could only improve to a certain level, showed evidence of holding both a fixed and growth mindset. School and interview data revealed that most students believed in the need to apply effort to improve school performance, however this did not necessarily equate with a student having a growth mindset for intelligence.
There was a significant difference between the mathematics growth mindset mean and the means of general growth mindset and English growth mindset for the school sample. The significantly lower mathematics mean implied that students had a more fixed mindset for mathematics. This significant difference was a key result that has implications for students’ future participation in mathematics. Furthermore, participation in mathematics was significantly related to having a growth mindset. Findings revealed that students’ mindsets were influenced by sociocultural and environmental factors.

This study highlights the importance of understanding self-theories or implicit beliefs about intelligence. Dweck (2015) reminds us to “never forget about the psychology of the student” (p. 243). How the student views themselves as a learner is critical for academic success. It is therefore important for students to understand their own implicit beliefs and whether these beliefs are detrimental to their learning. For schools in general, the development of students’ mathematics growth mindset may be beneficial in increasing mathematics participation in Years 11 and 12. It is recommended that teachers be mindful of their own implicit beliefs and recognise the importance of developing a growth mindset in their students.
Chapter One: Introduction

This study aimed to investigate the implicit theories of intelligence (mindset) in general, and about mathematics in particular, held by female students from years 7 to 12 in a single sex comprehensive secondary school. The introduction to this chapter outlines my own professional context and motivation to conduct the study. The matters raised in the professional context are then positioned within the broad and related literature that builds the rationale for the study.

Professional Context and Background

The College is a Catholic systemic school of 620 students located in the Central West of NSW. The College mission statement proclaims a Catholic faith community dedicated to excellence in the education of young women. As a former principal of this school from 2011 to 2016, I envisioned my role as ensuring that it provided an excellent education for all girls by allowing them to maximize their learning opportunities and to support them in this journey. Through my conversations with students, staff and parents, I became aware that some students did not achieve as highly as expected, and their engagement in school educational experiences was minimal. I noted with concern that some students:

- completed coursework at a minimal level or not at all, leading to low school assessment marks;
- had poor coping skills, lacked resilience and experienced anxiety;
- exhibited self-handicapping behaviours of absenteeism, truancy and missed assignment submission timelines;
- showed lack of interest, expressed boredom and attempted to leave school before the mandatory school age of 17 years; and
- failed to complete year 12, therefore not attaining the Higher School Certificate.

In particular, I noted that most students did not select the higher level Mathematics courses; and furthermore, many elected not to study Mathematics at all.
These trends raised questions as to why students were limiting their achievement, particularly in mathematics. What did students believe about their own intelligence or abilities? Did students believe they had the ability to complete work in years 11 and 12? Did they consider themselves ‘smart enough’? Why did some students not give up, even when the going was difficult for them? Why did some students interpret obstacles as mere setbacks rather than indications of inadequacy? Why did some students interpret failure as an indictment of their abilities and try to ‘save face’ by resorting to self-handicapping strategies? Concern was that sometimes students defended against the threat of incompetence by ‘opting out’.

The questions and issues posed here provide the professional background for this study: a study of student ‘mindset’ (implicit theories of intelligence) with a specific focus on mathematics, in an all girls’ school. Carol Dweck’s (2000, 2006) work on self-theories or mindset has resonated with my personal and professional experiences and holds considerable possibilities to enhance adolescent learning. The majority of studies on mindset have been undertaken internationally (Burnette, VanEpps, O’Boyle, Pollack & Finkel, 2013; Zhang, Kuusisto & Tirri, 2017) however there have been many studies in the Australian context on mathematics and gender, and to a lesser extent on mindset. Very few studies combine mindset, mathematics and gender. These studies will be reviewed in Chapter Two. This study uses a mixed methods approach in order to fill a gap in the literature combining three major fields of study; mindset, mathematics and gender. The investigation of mathematics mindset provides a lens through which to view the problem of declining female participation in post-compulsory secondary mathematics.

The Research Context

The research context includes an overview of the theory of mindset and its relationship with student motivation; a discussion of the recent trends in mathematics participation detailing factors influencing decline in mathematics participation, and the role of mindset in gender-related trends in motivation and participation in mathematics.

An overview of the theory of mindset and its relationship to student motivation.

As the study drew on Carole Dweck’s (2006), theory of mindset, it is imperative to explore the concept of mindset. Implicit theories and mindsets are conceptual terms, commonly used in educational and developmental psychology (Lüftenegger & Chen, 2017). The theory of
mindset provides a vital tool for examining student motivation in general, and for exploring some of the specific observations raised in my professional context. Dweck’s theoretical approach is concerned with individuals’ implicit beliefs about the extent to which they can change their intelligence, or other aspects of themselves. In this study, this approach provides a lens through which to understand how adolescent girls make sense of their world: how they construe situations, interpret events, process information and make meaning (Dweck, 1986). In particular, mindset is vital in understanding adolescent cognition and motivation. Dweck’s approach is a form of attribution theory. Attribution theory posits that the causal attributions people make about their successes and failures determine the impact of those successes and failures and shape their motivation (Weiner, 1985).

Dweck (2000) extends this perspective with a focus on individuals’ self-theories. She categorises people as having one of two types of mindset: fixed (entity theorists) or growth (incremental theorists). Dweck describes a fixed mindset as one which is based on the belief that our qualities are ‘carved in stone’; it is a belief in the innateness of ability, you either “have it” or you “don’t”. A growth mindset is based on the belief that qualities can be cultivated or improved through our efforts, which suggests that through application and experience, everyone can change. She contends that this fixed-malleable distinction is one that people apply to objects, processes and attributes. These distinctions enhance the perceived predictability of their world and serve as guides to behaviour in the world (Dweck, Chiu & Hong, 1995). Thus implicit theories refer to:

Beliefs that are not explicitly articulated in a person’s mind, but that form a schematic knowledge structure that guides a person’s perceived beliefs about his or her abilities, independent from their actual intellectual ability. (van Aalderen-Smeets & Walma van der Molen, 2016, p. 4)

Much of Dweck’s work has focused on individuals’ implicit theories about intelligence. Dweck argues that beliefs about the fixedness or malleability of intelligence are fundamental to human cognition and critical to our understanding of the world. The mindset of students is crucial in education. There is an increasing body of evidence supporting the existence of fixed and growth mindsets with regard to intelligence, and about the consequences of fixed and growth mindsets for student motivation and achievement. The vast quantity of research on mindset seeks to show relationships between mindset and goals; mindset and motivation and
mindset and achievement. Martin, Bostwick, Collie and Tarbetsky (2017) highlight the importance of implicit beliefs of intelligence and its relationship with academic motivation and engagement. Martin et al. point out that mindset is related to a range of factors and processes which are fundamental to students’ pathways through school such as students’ self-worth, their goal setting, their choice of tasks and task difficulty, their academic resilience and adaptability, their engagement and persistence and attributional patterns.

Intervention studies have shown that mindset can be altered with positive results for motivation and achievement (Blackwell, Trzesniewski & Dweck, 2007; Claro, Paunesku & Dweck, 2016; Tarbetsky, Collie & Martin, 2016). The research on mindset and its relationships with student motivation and achievement will be examined in detail further in this review.

Recent trends in mathematics participation.

Mathematics was a specific focus for this study for several reasons. The issues raised about mathematics in the school reflect a much more widespread trend. There is considerable evidence of declining participation in mathematics in Australia (Thomas, Muchatuta & Wood, 2009, Leder & Taylor, 2010, Murray, 2011) and internationally (Cann, 2009; OECD, 2014). Martin, Way, Bobis and Anderson (2015) showed that compared with Grade 6 students, students in Grades 7 and 8 have significantly declined in mathematics engagement from their previous year. In many countries students are increasingly opting out of higher levels of mathematics for their final years of secondary school (Murray, 2011). In Australia, between 1995 and 2007, the proportion of Year 12 students studying ‘advanced’ senior secondary mathematics courses had decreased by 27%, while the proportion of Year 12 students taking ‘Intermediate’ level mathematics had declined by 22%. However, the proportion of students who were undertaking ‘elementary’ senior secondary mathematics had increased by almost 30% (Brown, 2009). This trend is also reflected in the state of NSW where enrolments in general mathematics have increased by 12% in the last decade, while candidature for 2 unit mathematics has fallen by 16%. The number of students completing general mathematics for the Higher School Certificate (HSC) is now double the number studying the more challenging 2 unit mathematics (Tovey, 2013). The Australian Mathematical Sciences Institute (AMSI) released data showing that the number of Year 12 students selecting higher level mathematics subjects dropped gradually between 2006 and 2015 (Education Review, 2016).
Furthermore, Attard (2009) notes that “many students fail to enjoy or see the personal relevance of mathematics and few voluntarily continue its study” (p. 41).

This decline is a matter for significant concern, for reasons related to both national economic growth and social equity. The decline in student participation in mathematics in secondary school has flow-on effects for what has been termed the mathematics pipeline (Stage & Maple, 1996), resulting in some countries having a long-term decline in the number of students majoring in mathematics at the undergraduate level (Holton, Muller, Oikkonen, Sanchez Valenzuela & Zizhao, 2009). The reduction in the number of young people studying post-compulsory mathematics also has implications for the uptake of mathematics-based subjects such as science, technology and engineering. The Science, Technology, Engineering and Mathematics (STEM) disciplines are crucial to the economic competitiveness of a nation and our future prosperity (Chubb, 2013). A strong education in STEM has been heralded as the key to personal and intellectual development in modern society and also the key to the economic development of nations (Rodriguez, Romero-Canayas, Downey, Mangels & Higgins, 2013). In 2003, the percentage of students graduating with a major in mathematics or statistics from Australian universities was 0.4% compared with an OECD (Organisation for Economic Co-Operation and Development) average of 1%. This has narrowed the mathematical research base and limited the supply of adequately qualified mathematics teachers (Rubinstein, 2009). The National Strategic Review of Mathematical Sciences Research in Australia concluded that:

Australia’s distinguished tradition and capability in mathematics and statistics is on a truly perilous path … and by neglect of the basic principle that mathematics be taught by mathematicians and the supply of students and graduates is falling short of national needs. The mathematical sciences skill base in any country is too important for its future prosperity to let short-term market mechanisms act alone. (Hughes & Rubinstein, 2006, p. 1)

Participation in post-compulsory mathematics also has profound implications for social justice and equity. Sells (1978) seminal work recognised that mathematics acts as a critical filter which limits access to many high-status high-income careers. In agreement with Sells, Shapka, Domene and Keating (2006) point out that mathematics acts as a filter by limiting
students’ future options. They found that youth who performed poorly in Grade 9 mathematics aspired to careers that were of lower prestige. Mathematics has also been described as a gatekeeper to economic access and higher education (Hemmings, Grootenboer & Kay, 2011; Stinson, 2004).

**Factors influencing decline in mathematics participation.**

There are many potential factors which explain the decline in mathematics participation with implications for both parenting and teacher practice (Hemmings et al., 2011). Marks and McMillan (2003) address issues of socio-economic inequality as a possible factor. They conclude, however, that student ability has a stronger effect on educational outcomes than socio-economic background. G. Marks (2013) also found that student ability and occupational interests have a much stronger impact than socio-economic background on subject selection at senior level and the choice of university subjects. Watt, Hyde, Petersen, Morris, Rozek and Harackiewicz (2017) in their longitudinal study of Australian and U.S. adolescents noted that Australian females would not plan to pursue a STEM-related career unless they thought they were ‘good’ at mathematics.

To date, there has been relatively little research examining attitudes towards mathematics informed by the mindset theoretical framework (Boaler, 2013, 2016; Dweck, 2008; Martin, 2015a). Boaler (2013) emphasises that mathematics is an important area for growth related research due to declines in interest and participation by students. Mathematics is a subject area about which there are strong beliefs regarding the role of ‘natural’ ability for success. Thus, the theory of mindset offers a potentially valuable way of understanding students’ attitudes towards and participation in mathematics. The research on attitudes to mathematics and its potential links with mindset will be explored later in the literature review.

**The role of mindset in gender-related trends in motivation and participation in mathematics.**

All of the trends discussed regarding mathematics are more marked for females than for males, both in Australia and in many other countries (Cann, 2009; Watt, 2005). Gender differences seem to increase as students’ progress through school (Forgasz & Leder, 1996).
These trends will be discussed briefly here, and will be examined more fully in an exploration of the links between mathematics, gender and mindset.

Australian Government policy documents and reports targeting girls’ mathematics education testify to a level of concern with girls’ lower participation in post-compulsory mathematics (Watt, 2006). Girls were more likely than boys to opt out of the more difficult levels of mathematics, or not undertake any mathematics at all (Watt, 2006). Over the period, 2007-2009, Forgasz and Hill (2013) reported that VCE (Victorian Certificate of Education) mathematics results showed a clear pattern of male dominance amongst the highest achievers in all of the examined mathematics subjects. Women and girls are under-represented in STEM subjects throughout their education and careers (Marginson, Tytler, Freeman & Roberts, 2013). This under-representation has strong implications for females’ ability to pursue mathematics related careers, consistent with the notion of mathematics as a ‘critical filter’ (Sells, 1978). As females progress to higher educational and professional levels their participation in mathematics decreases (Watt, 2005). From a gender equity perspective, this may mean that girls do not share equally in the advantages of the mathematically well-prepared and from an economic viewpoint represent an ‘under-utilised’ pool to supplement the shortage of people in the STEM careers (Watt, 2007). Dodd (2016) reports that the Australian Institute of Mathematical Sciences (AMSI) notes that “efforts to bring more girls into advanced mathematics courses has not paid off, with 6.8 per cent of Year 12 girls studying mathematics in 2014 compared to 13.3 per cent of boys” (p. 1). AMSI Director, Geoff Prince voiced his concerns:

An entrenched gender divide and a critical failure to engage younger generations continue to pose a very real threat to Australian’s innovation future ... There is a real shortage of skills in the mathematical sciences at a time when data sciences are so important. (Dodd, 2016, p. 1)

There is a need to better understand the factors contributing to these gender-related trends. Psychological and sociological research can provide insights into these trends. Psychological research indicates that part of the explanation for the gender difference in mathematics participation lies in the fact that girls’ perceptions related to mathematics are different to boys. Girls have less confidence in their mathematical abilities and experience more anxiety
than boys (Brown, Brown & Bibby, 2008; Cann, 2009; Lloyd, Walsh & Yailagh, 2005; Maloney, Schaeffer, Beilock, 2013; Morge, 2005; OECD, 2014; Watt, 2007). Furthermore, girls don’t feel that they ‘belong’ in mathematics (Brandell & Staberg, 2008; Good, Rattan & Dweck, 2012; Nosek, Banaji & Greenwald, 2002; Rodd & Batholomew, 2006). Girls may see themselves as existing on the margins of the practice – with a fragile mathematical identity (Solomon, Lawson & Croft, 2011). Furthermore, girls rate themselves as having lower ability than boys (Boaler, 1997a; Mendick, 2005b; Yeung, 2011) and typically assess their mathematical abilities lower than do boys with similar mathematical achievements (Heilbronner, Shea & Reis, 2010). Girls were more apt to attribute mathematics failure to a lack of teachers’ help than boys (Lloyd et al., 2005). PISA results show that:

Even when girls perform as well as boys in mathematics, they tend to report less perseverance, less openness to problem solving, less intrinsic and instrumental motivation to learn mathematics, less self-belief in their ability to learn mathematics and more anxiety about mathematics than boys, on average; they are also more likely than boys to attribute failure in mathematics to themselves rather than to external factors. (OECD, 2014, p. 18)

These consistent findings raise further questions: why is it that girls perceive themselves as having less talent or ability, and lower expectations of success at mathematics than boys, even though their mathematical achievement or performance is similar? Sociological research offers some insight into this question. Mendick (2005a) argues that there are powerful cultural discourses surrounding mathematics. It is widely viewed as a narrow and exclusive academic field and seen as a signifier of intelligence (Mendick, 2008). These discourses socially construct ‘mathematical ability’ as natural, individual and masculine, which makes it more difficult for girls and women to identify as “good at mathematics” (Mendick, 2005b, p. 204).

To date, there has been very little research that has explored the issues of gendered attitudes and participation in mathematics from the perspective of implicit theories of intelligence. However, the theory of mindset offers great insight into these trends. Mathematics is a subject which is culturally aligned with a fixed mindset: it is often seen as a subject for which you either have the ability or not and this ability is viewed as “unchanging, natural and located within the person” (Mendick, 2008, p. 712); it is viewed as a difficult subject (Mendick, 2005a);
and finally, it is seen as a male domain (Mendick, 2005b). Gunderson, Ramirez, Levine and Beilock (2012), suggest that it would be useful to use Dweck’s approach to mindset to study issues of mathematics and gender. Park, Gunderson, Tsukayama, Levine and Beilock’s (2016) findings add to a growing literature supporting the importance of motivational frameworks and mathematics achievement. They provide evidence that by first and second grade, children already differ in their beliefs about the stability of academic ability and the value of effort and in their preference for challenging rather than easy tasks.

**Aims and Research Questions**

The broad aim of this study was to investigate the implicit theories of intelligence (mindset) held by female students from Years 7 to 12 in a single sex comprehensive secondary school. A second aim was to explore the relationship between students’ mindsets regarding mathematics in particular, and their participation in mathematics. A third aim was to examine students’ perceptions of the factors influencing their mindset.

The research was guided by the following five questions:

1. What implicit theories of intelligence or mindset do female secondary students hold? In particular, what beliefs do they hold about ability and effort and their roles in academic achievement?

2. What is the relationship between these beliefs and students’ self-reported learning behaviours?

3. What implicit theories of intelligence specifically related to mathematics do female secondary students hold?

4. What is the relationship between these beliefs and their participation in mathematics?

5. What are students’ perceptions of the factors influencing their beliefs about intelligence in general and ability in mathematics in particular?
Significance of the Study

The research is significant because it will lead to a nuanced understanding of mindset and how it impacts on motivation and achievement, in the naturalistic setting of an Australian, single sex, secondary school. It will fill a gap in the literature because the research will combine three major fields of study; mindset, mathematics and gender. Our understanding of mindset will be extended and deepened by the use of qualitative methods such as semi-structured interviewing to hear the student voice. Howe and Berenson (2003) recommend the “documentation of girls’ voices to report their perceptions of what it takes for them to be successful in advanced mathematics classes” (p. 87). Murray (2011b) pointed out that many recent studies “have explored the notion of high quality or effective mathematics teaching but relatively few have sought the views of students” (p. 14). Attard (2013) emphasised the “use of the student voice and comparison of their perceptions of mathematics teaching and learning with existing research literature and frameworks for effective teaching of mathematics to provide rich insights into what constitutes effective teaching of mathematics” (p. 585).

An investigation of mathematics mindset will also provide a lens through which to view the problem of declining student participation in post-compulsory secondary mathematics.

Thesis Overview

This study comprises ten chapters that examine students’ implicit theories of intelligence in general (general mindset), and implicit theories of intelligence specifically related to mathematics (mathematics mindset), in an all-girls secondary school. Following this introduction, Chapter Two provides a review of the literature on implicit theories of intelligence and the neurological studies related to mindset; the implications of mindset for student motivation and achievement and the outcomes of mindset intervention studies. Psychological and sociological research that connects mindset, mathematics and gender is reviewed as well as the factors which influence mindset such as the role of culture, schooling and the use of praise. Chapter Three outlines the pragmatic and methodological decisions made for the collection and analysis of data in this thesis. This study adopted a mixed method approach to data collection with both questionnaire (quantitative) and interview
(quantitative and qualitative) sources of data. Chapters Four, Six and Eight comprehensively address the research questions and present the findings of this study. Chapters Five, Seven and Nine each discuss the findings in relation to the previous chapter. Chapter Ten includes an overall discussion and conclusion for the study.
Chapter Two: Literature Review

Introduction

The theory of mindset provides an important framework for understanding student motivation and related learning behaviours. The empirical research has provided consistent evidence linking mindset to motivation, usually through one or more mediating variables (Dupreyrat & Mariné, 2005; Kinslaw & Kurtz-Costes, 2007; Martin, 2015b; Renaud-Dubé, Guay, Talbot, Taylor & Koestner, 2015; Robins & Pals, 2002; Tempelaar, Rienties, Giesbers & Gijselaers, 2015). The background literature on mindset and its implications for motivation and achievement were developed from psychological, educational and sociological research. The construct brings together many different fields of endeavour and hence the subject’s complexity. This literature review draws on the research from three major fields of study, mindset, mathematics and gender to explore female students’ implicit beliefs about intelligence and their participation in mathematics in an Australian all girls’ secondary school.

In the academic achievement and motivation domains, the last three decades of educational and psychological research have been especially productive in terms of the rationale for the use of the construct of self-theories or implicit theories (Dweck & Leggett, 1988). Mindset research is both contemporary and dynamic as the research is current and continuously evolving. Dweck (2015, 2017) and Hattie (2017) continue to defend misinterpretations of the growth mindset that have perhaps arisen due to overzealous use of mindset research. Dweck (2015) has emphasised that ‘growth mindset’ is not an “attribute of a person but rather a way of thinking in a particular circumstance ... more of a coping strategy than a state of being” (p. 2). Dweck’s original research arose from her work on learned helplessness (Dweck, 1975, 1980), which led to an understanding of when and where the growth mindset can be invoked to lead to better outcomes. Dweck, Chiu and Hong (1995) believed that it is was possible for an individual to hold both incremental and entity theories of intelligence, “albeit to differing degrees” (p. 323). Their research highlighted the conditions under which the fixed mindset may be detrimental for achievement such as in response to challenge, mistakes and failure. Following her work on self-theories and their role in motivation, personality and development (Dweck, 2000), Dweck’s seminal work on ‘Mindset’ (2006), captivated the public imagination and she has been described as the:
Famous researcher whose books on mindset have revolutionised people’s lives, across
continents and whose work has moved governments, schools, parent and even
leading sports teams to approach life and learning differently. (Boaler, 2016, p. ix)

The review of the mindset literature for this study extends from 2000 to 2018 with some
reference to earlier work by Dweck and her colleagues in the mid-nineties that underpinned
mindset. Although mindset research originated in the United States, the research on mindset
and the implications for educational practice have been taken up internationally (Bråten, Lien
& Nietfeld, 2017; Dahlin & Watkins, 2000; Dandy & Nettlebeck, 2002; Dupeyrat & Mariné,
Magno, 2012; Mouratidis, Michou & Vassiou, 2017; Verniers & Martinot, 2015; Zeng, Hou &
Peng, 2016). In particular, Asian countries such as China and Singapore have taken a special
interest in mindset theory due to their country’s emphasis on striving to improve culturally
linked to the philosophy of working hard (Chan, 2012; Chen & Wong, 2014; Luo, Lee, Ng &
Ong, 2014; Wang & Ng, 2012).

There has been some exploration of Dweck’s implicit theories of intelligence in the Australian
context, with contributions from Bornholt and Möller (2003); Crick and Goldspink (2014); De
Castella and Byrne (2015); Martin (2015a, 2015b); Martin, Bostwick, Collie and Tarbetsky
(2017); Masters (2013); Tarbetsky, Collie and Martin (2016); Thompson and Musket (2005).
Australian research on the participation and achievement of students in mathematics is more
extensive including some emphasis on gender (Attard, 2009; Forgasz, 1998; Forgasz & Hill,
2013; Forgasz & Leder, 1996; Grootenboer & Hemmings, 2007; Hemmings, Grootenboer &
Kay, 2011; Leder & Forgasz, 2008; Murray, 2010, 2011; Thomas, Muchatuta & Wood, 2009;
Watt, 2007; Watt, Eccles & Durik, 2006; Watt, Hyde, Petersen, Morris, Rosek & Harackiewicz,
2017). However, there has been very little research linking mindset, mathematics and gender
in the Australian context, although there are some notable exceptions. The study by Bostwick,
Collie, Martin and Durksen (2017), on mindset, goals and academic outcomes, with over 4,411
students in grades seven to nine from 19 secondary schools across three states in Australia;
Tully and Jacobs (2010) who focused on female engineering students and the influences of
their secondary school experience on their choice to pursue engineering and Sullivan, Tobias
and McDonough (2006) who conducted interviews on engagement in mathematics with 50
grade eight students. However, Hemmings and Kay (2010) did not research student implicit
beliefs of intelligence related to mathematics but did note that effort, in particular is “a notion worthy of further investigation” (p. 41).

In order to answer the research questions of this study it was necessary to explore and critique a breadth of mindset ‘methodologies’. The research evidence, that mindset is related to achievement, comes from correlational studies and mindset interventions both of which are reviewed in this chapter. Although I have ‘touched’ on the benefits of the growth mindset for the affective domain of learning (King, McInerney & Watkins, 2012; Schleider & Weisz, 2016), the topic is broad and beyond the scope of this study. Neurological studies (Myers, Wang, Black, Bugescu & Hoeft, 2016; Tirri & Kujala, 2016) that demonstrate the capacity of the brain for intellectual growth and change which supports mindset theory are also not a primary focus of this study, however the research implications for student learning cannot be ignored. Many factors may influence the development of mindset, such as students’ upbringing by their parents and families, and the impact of gendered attitudes and cultural practices. The research on the influence of parents and culture on mindset is extensive and acknowledged in this review. To a lesser extent, the literature on the parental use of praise affecting mindset, while reviewed is again beyond the scope of this study.

Mindset research has explicit implications for school practice. In my role as a teacher and former principal of the case study school, school practice is important. Therefore, for the purposes of this study, the school context is the major focus. The literature review examines school based practices such as stage and grade issues and the nature of peer pressure. The use of praise by teachers and parents is explored, as well as gender identity, disparities and achievement.

Different learning conditions, different contexts and in this study, different school subjects can invoke different mindset responses (Dweck, Chui & Hong, 1995; Mercer & Ryan, 2010). The concern for the continuing decline in mathematics’ participation in senior secondary school, gave rise to the second major focus area for this study and the literature review, which is the subject of mathematics and mindset. Mathematics may communicate the strongest, fixed ability messages and thinking (Dweck, 2008; Boaler, 2013). The literature is reviewed in terms of the psychological research on gender differences in attitudes towards mathematics and a complementary broader perspective of sociological research in which prevailing attitudes, beliefs and stereotypes regarding mathematics are explored.
The literature review is presented in five sections. The first section revisits the major ideas underpinning the implicit theories of intelligence and provides a brief overview of recent neurological research which validates the idea of a growth mindset. The second section draws on theoretical and empirical research within education about mindset, focusing on student motivation, learning behaviours and achievement and exploring the evidence from correlational and intervention studies. The third section examines some of the factors that influence mindset, such as culture, school practices, the use of praise by parents and teachers and gender stereotyping. The fourth section examines the relationship between mindset, mathematics and gender. Finally, the conclusion is presented.

**Implicit Theories of Intelligence – Mindset**

According to Dweck, an individual has one of two types of mindsets about intelligence (2000, 2010):

1. an entity or fixed mindset is the belief that intelligence is a fixed or innate trait; and
2. an incremental or growth mindset is the belief that intelligence is malleable and influenced by experience and learning.

A person with a growth mindset believes his/her intelligence or brain can be developed by various means, through effort and instruction. Having a growth mindset involves a belief that the brain ‘gets more clever’ with practice, and thus, this is a view which is inherently hopeful (Dweck, 2015). On the other hand, a person with a fixed mindset believes intelligence is a static trait: some people are smart and some are not and that’s the way it is. This can lead to less effort or diligence and loss of hope, especially when a student does not perform well. Kristjansson (2008) notes that the implicit theories or beliefs that Dweck describes “penetrate to the very core of an individual’s being; they are self-shaping” (p. 225).

Dweck (2000) has found that the trait beliefs people have about their own intelligence largely determine their motivation, goals, effort and outcomes during the process of learning. Dinger, Dickhäuser, Spinath and Steinmayr (2013), explain that “individuals approach academic settings differently depending on their implicit theory of intelligence because these subjective beliefs affect how individuals experience achievement situations” (p. 91).
Implicit theories of intelligence or mindsets are important for understanding differences in student classroom performance and for predicting long term achievement differences. Shively and Ryan (2013) point out that different implicit theories of intelligence across academic domains would have consequences for student achievement in these domains. These implications will be explored later in the literature review.

The term intelligence has many definitions in the academic context (Nettlebeck & Wilson 2005; Sternberg & Grigorenko, 2004) and the term effort is a construct frequently considered in educational contexts (Stables, Murakami, McIntosh & Martin, 2014). However, as Hemmings and Kay (2010) point out, there are few direct references to a measure of the construct in the school achievement research literature. While it would be expected that the concepts of intelligence and effort central to mindset would be defined, I have purposely not done so, as one of the research aims for this study was to explore students’ beliefs about intelligence and effort in academic achievement and participation in mathematics. Also, for the purposes of this study, I have used the terms intelligence and ability interchangeably as originally conceptualised by Dweck in her seminal work on mindset (2000, 2006).

Dweck like Wechsler (1974) and Li and Lee (2004), recognised motivation as being part of intelligence for optimal intellectual functioning. Li and Lee (2004), emphasised that “beliefs about the nature of ability are critical elements to all other major theories…which directly affect motivational patterns and outcomes” (p. 439).

My research focus is not concerned with a measure of intelligence or ability but rather concerned with the students’ understanding and conceptualisation of ability, their self-belief or mindset.

**Neurological studies related to mindset.**

The psychological research related to mindset has been validated by recent studies in the field of neuroscience. While neurological studies are not a specific focus of this research the following section provides useful evidence demonstrating the capacity for intellectual growth and change. Research on neuroplasticity represents a burgeoning field.

The previous view that the brain was “hard wired”, immutable, or something one is “born with” has given way to the study of brain plasticity; the capacity of the nervous system to
change its organization and function over time (Hyde, 2007, p. 62). Kuszewski (2011) defines plasticity by the number of connections made between neurons; how that affects subsequent connections and how long-lasting those connections are. Brain plasticity can be affected by many factors such as, experience, stress, drugs, hormones and maturation.

It was once thought that when a person reaches adulthood, their cognitive abilities were immutable. However, research on brain function suggests that the brain’s abilities are in fact malleable and plastic. According to this principle of neuroplasticity, the brain is constantly changing in response to various experiences. New behaviours, new learnings may all stimulate the brain to create new neural pathways or reorganize existing ones, fundamentally altering how information is processed (Hardy & Scanlon, 2009).

There is growing interest in neurological research on the neurological mechanisms that underlie mindset. One study, by Mangels, Butterfield, Lamb, Good and Dweck (2006), measured event-related potentials (ERPs)-electrical brain signals elicited by external or internal events-in college students endorsing a fixed or growth mind-set while they performed a difficult general knowledge test. Compared with fixed-minded individuals, they found that growth-minded individuals allocated more attentional resources to corrective information following error feedback and were more likely to correct their mistakes on a surprise retest.

Moser, Schroder, Heeter, Moran and Lee (2011), extended the findings of Mangels et al. (2006) by studying the ERPs elicited during error processing that related to adaptive behavioural adjustments following mistakes. Moser et al.’s research indicated that more growth-minded individuals showed superior accuracy after mistakes compared with individuals endorsing a more fixed mind-set. Growth-minded individuals showed the ability to rebound from mistakes. The neural underpinnings of growth mindsets and their links to adaptive responses to mistakes has important implications for academic performance.

Growth and fixed mindset messages may have differential effects on the neural dynamics underlying cognitive control. Schroder, Moran, Donnellan and Moser (2014) assessed how a mindset induction influenced cognitive control brain activity. The study was designed to integrate mindset research with cognitive neuroscience by delivering brief mindset messages to undergraduate participants just before they completed a reaction-time task (Eriksen
flanker task), during which time event-related brain potentials (ERPs) were recorded. Their findings revealed that inducing a growth mindset resulted in enhanced attention to task-relevant stimuli, however inducing a fixed mindset enhanced attention to responses. Unfortunately, despite enhanced attention to responses in the fixed mindset group, this attention allocation was unrelated to adaptive performance adjustments whereas the growth mindset induction produced a coupling between error-related attention allocation and adaptive post-error performance. As the previous study centered on adults, Schroder, Fisher, Lin, Lo, Danovitch and Moser (2017) extended their work with 123 children completing a child friendly go/no-go task. After completing the mindset measure, electrodes were applied and the children were seated in front of a computer monitor to complete the error-monitoring task. The growth-minded children demonstrated enhanced amplitude of the Pe, an ERP (event-related potential) linked with attention allocation. These children also had better accuracy after mistakes. This finding supports the work of Molden and Dweck (2006), whose observation that following failure on a task, growth-minded people were more likely to focus on determining how to bring about improvements in completing the task.

Myers, Wang, Black, Bugescu and Hoeft (2016) sought to further the understanding of the similarities and differences between grit (long-term perseverance for a goal or set of goals) and growth mindset by examining associated brain networks in a sample of 20 children using resting state functional connectivity (RSFC). RSFC, measured by functional magnetic resonance imaging (fMRI) is thought to reflect the brain’s functional organization. Both grit and growth mindset are associated with cortico-striatal networks associated with learning. The research results indicated that growth mindset was associated with both ventral and dorsal striatal connectivity with regions of the brain thought to be important for error-monitoring and hence correcting mistakes. Students desirous of mastering their learning will want to be aware of errors, correct mistakes and persist. The results of these experimental studies have implications for educational research on mindset as active brain engagement indicating mastery oriented behaviours were exhibited by students with a growth mindset.

Understanding that the brain physically changes during learning and that one can effect such changes with effort has considerable significance for students (Tirri & Kujala, 2016). Indeed, understanding how learning and memory are constructed from one’s own repeated and relevant experiences adds to students’ metacognitive knowledge, an essential component for
educational success (Fitzakerley, Michlin, Paton & Dubinsky, 2013). Adey, Csapó, Demetriou, Hautamäki and Shayer (2007) argue that education needs the concept of plastic general ability. If students understand that the brain can change with learning and that this requires effort on the part of the learner, then this may shift students from embracing a fixed mindset to a growth mindset.

**Implications of Mindset for Student Motivation and Achievement**

Dweck and other researchers argue that implicit theories of intelligence play a key role in academic motivation and achievement (Blackwell, Trzesniewski & Dweck, 2007; Chen & Pajares, 2010; Dinger & Dickhäuser, 2013; Tarbetsky, Collie & Martin, 2016).

The following section examines the empirical research on mindset and its relationship to student motivation and achievement. It describes the adaptive and maladaptive motivational patterns associated with growth and fixed mindsets, including differences in learning goals, response to challenges, the way in which effort is perceived and differences in the affective domain. Some of the research has been correlational in nature: investigating statistical associations between measures of implicit theories of intelligence and motivational variables. However, much of the research has been within an experimental social psychology paradigm. These studies have involved short term manipulation of subjects’ implicit beliefs of intelligence and measuring subsequent performance or behaviours. Other studies have examined the effect of longer term interventions designed to encourage a growth mindset in participating students. The evidence to date about the long term impact on academic outcomes is limited but encouraging.

**The relationship between mindset and motivation.**

The theory of mindset provides an important framework for understanding student motivation and related learning behaviours. The relationship between mindset and motivation is explored by examining the importance of student learning goals; student responses to challenge, mistakes and failure, student interpretation of the need for effort and student well-being.
Mastery/Performance learning goals.

Students’ beliefs about intelligence lead them to choose particular learning goals which in turn establish different behaviour patterns (Elliott & Dweck, 1988; Robins & Pals, 2002). Goals involving competence appear to fall into two classes: learning or mastery goals in which individuals seek to increase their competence, to understand or master something new and performance goals, in which individuals seek to gain favourable judgements of their competence or avoid negative judgements of their competence (Dweck, 2000). According to Dweck, entity theorists, that is, those with a fixed mindset, will tend to adopt a performance approach, whereas incremental theorists, that is those with a growth mindset, are more likely to prefer a mastery approach to learning. Students with a fixed mindset worry about how much intelligence they possess. When students have a fixed mindset they may value looking smart over learning. Dweck (2006) argues that these students may not care to explore topics in depth; nor be disposed to engage in critical thinking to gain and share knowledge; are low on self-accountability and self-assessment strategies. Students with a fixed mindset have goals of documenting their ability, winning positive judgments of their competence and avoiding negative ones. They want to look ‘smart’, not ‘dumb’. They would prefer easy, low-effort successes, and outperforming other students to show they are smart. On the other hand, students with a growth mindset have goals aimed at increasing their competence, reflecting a desire to learn new skills, understand more and have a desire to get ‘smarter’. Ablard and Mills (1996) succinctly summarises the two learning approaches: incremental (growth mind-set) theorists focus on acquisition of competence, entity (fixed mind-set) theorists’ focus on the confirmation of competence (p. 138). These core beliefs can set up different patterns of response to challenge and setback (Dweck & Leggett, 1988; Dweck, 2000). Students with the lowest skills in self-regulated learning (SRL) were found by Ablard and Lipshultz (1998) to have low performance and mastery goals. As mastery goals increased, so did the greater use of self-regulated strategies.

Other researchers, such as Covington (2000), who reviewed the direction and progress in our understanding of the motivational dynamics of school achievement, adds to the picture by highlighting the factors involved. The quality of student learning and the desire to continue learning involves an interaction between the kinds of academic and social goals students may have, how these goals motivate them to continue learning, and the prevailing reward
structures used by teachers. This is also integral to Dweck’s research as having performance goals by striving for good grades and caring for learning are not necessarily incompatible goals as in some situations they may be mutually reinforcing. Midgley, Kaplan and Middleton (2001) emphasise caution in promoting performance goals as there may be a cost in terms of students avoiding certain strategies, cheating and reluctance to cooperate with peers.

Response to challenge, mistakes and failure.

Failure, or not doing as well as expected, has different meanings in the entity and incremental-theory frameworks (Elliott & Dweck, 1988). According to Dweck (2006), the adaptive or mastery oriented pattern is characterised by challenge seeking and high, effective persistence in the face of obstacles. In contrast, the maladaptive or helpless pattern is characterised by challenge avoidance and low persistence in the face of difficulty. In the incremental-theory framework, mistakes and failure will prompt the response of how to best acquire this skill or master this task. Students with this growth mindset believe that intelligence is a potential to be realised through learning. As a result, confronting challenges, profiting from mistakes and persevering when setbacks strike become ways of being smarter. In contrast to this, in the entity-theory framework, mistakes and failure can be interpreted to mean low intelligence and the questioning of whether one’s ability is adequate (Elliott & Dweck, 1988). Holding an entity theory or fixed mindset is not a belief system that breeds security according to Dweck et al., (1995), as one has to keep looking at reflections of it in performance to reassure oneself of its adequacy. Experiencing poor performance or failure can pose a threat to self-esteem which can be expressed as anxiety, boredom, defiance, a sense of shame, devaluation of a task and depressed effort (Dweck & Leggett, 1988).

Hong, Chui, Dweck, Lin and Wan (1999) found that when incremental (growth) theorists were given negative feedback, they were more likely than entity (fixed) theorists to attribute poorer performance to lack of effort and were more likely than entity theorists to take remedial action to improve their performance. After receiving negative performance feedback, entity theorists showed greater frontal P3 response in the brain, which is a sign of higher fixation on negative feedback and greater self-critical thoughts, than incremental theorists (Mangels et al., 2006). When students experience a set-back, remedial action is required; there is a need to focus on their effort and strategies and to avoid feelings of
incompetence. The evidence of differing brain function lends support to the different implicit beliefs of entity and incremental theorists.

Most at risk, according to Ablard and Mills (1994), may be able students with entity views and inaccurately low perceptions of their ability; and bright girls who have had success in primary school but may be ‘motivationally vulnerable’ faced with the transition to high school (Dweck, 2006). The authors speculate whether the underachievement of ‘gifted’ students may be due to a fixed mindset.

Park and Kim (2015) add another interesting dimension to the entity versus incremental mindset response after failure. They argue that people demonstrate adaptive or maladaptive responses to failure depending on their perception of a task and this is why entity theorists can sometimes perform better than incremental theorists. For example, in their study, on a series of tasks, incremental theorists performed worse when a subsequent task measured a different ability, preventing them from trying harder at the previous task they had just failed. In contrast, entity theorists performed worse when the subsequent task measured the same ability as the first task, a task they believed they could not accomplish. Park and Kim’s (2015) results suggest that specific types of thoughts might be related to performance such that “performance on the second task was only influenced by self-critical thoughts, but not by self-enhancing thoughts” (p. 746). They suggest that not only do we need to consider individual’s implicit theories of intelligence but also the perceived relationship between different tasks.

Examining Singapore secondary students’ incremental beliefs of mathematics ability, Luo, Lee, Ng, Ong (2014), found that incremental beliefs were associated with an adaptive pattern of achievement emotions, classroom engagement and mathematics achievement. Likewise Chan (2012) in a study of the growth mindset of healthy and unhealthy perfectionists among Hong Kong gifted students, found that the healthy perfectionists scored significantly higher on the growth mindset scale than the non-perfectionists and the unhealthy perfectionists scored significantly higher on the fixed mindset scale than the healthy perfectionists and the non-perfectionists. These studies highlight the importance of intelligence mindsets and their relationship with other factors that impact on a students’ achievement and performance in school.
The meaning of effort, the application of effort and self-handicapping.

The term effort is central to a discussion on mindset. The term is multidimensional and Stables, Murakami, McIntosh and Martin (2014) revealed that understandings of effort are “not uniform, a fluid shorthand term, for some, still defying a consensus in definition and being afloat in a complex schooling process” (p. 19). Exploring students’ understanding of effort is at the heart of this study as I am endeavouring to find out what students actually think effort is in terms of their learning behaviours, as well as how they understand effort in relation to intelligence.

Effort has different meanings in the two mindsets: students with an entity theory of intelligence may think that effort, difficulty and setbacks may call their intelligence into question, whereas students with an incremental theory view effort as necessary to become more intelligent (Blackwell et al., 2007). These different mindsets lead to students adopting different learning behaviours. Stipek and Gralinski (1996) found that students with a fixed mind-set had little faith in the effectiveness of effort. Beliefs about ability affect student decisions about whether or not to exert effort and to pursue courses that were challenging (Anderson, 2009). Students who saw ability as fixed were less likely to persist and solve problems than students who saw ability as amenable to effort (Hodgen, Marks & Pepper, 2013). Students with a fixed mindset showed a declining motivation over the school year (Haimovitz, Wormington & Corpus, 2011). Students with a fixed mindset were more likely to give up on a task when faced with adversity (Zuckerman, Gagne & Nafshi, 2011). Fixed beliefs predicted higher homework procrastination and lower study efforts (Mouratidis, Michou & Vassiou (2017). In contrast, students with a growth mindset showed less procrastination than those with a fixed mindset (Howell & Buro, 2009). A growth mindset was the best, negative predictor of work avoidance (Dupeyrat & Mariné, 2005). Students with a growth mindset were more likely than those with a fixed mindset to adopt constructive academic strategies. The former devoted more effort to a learning task, and were willing to try again after failure (Hong et al., 1999). They also tended be more diligent in their work, demonstrating more concentration (Ommundsen, Haugen & Lund, 2005), and to use study strategies that were more effective and required more effort (Jones, Slate, Marini & DeWater, 1993). “Academic underdogs”, that is those students who do not achieve as well as others and earn lower course completion grades, benefited from a growth mindset, as they coped more effectively when
academic challenges arose (Davis, Burnette, Allison & Stone, 2011, p. 333). High resourceful students with a growth mindset were more academically resourceful than high resourceful students with a fixed mindset (Kennett & Keefer, 2006). Resourceful students made use of positive self-instruction, applying problem solving methods, delaying gratification and other self-control strategies. Hochandel and Finamore (2015) reported that grit defined as “passions and persistence for long-term goals” (p. 47) by Duckworth and Quinn (2009), could be developed by having a growth mindset.

**Self-handicapping.**

Studies related to self-handicapping (Hirt & McCre, 2009; Warner & Moore, 2004), help to explain the relationship between mindset and academic behaviours and also illuminate the role of effort in student achievement. Self-handicapping is a particular form of behaviour that is problematic in learning as it prevents the student from reaching his/her full potential. Self-handicaps are obstacles to successful performance that are constructed by a person to protect or enhance his/her self-esteem (Zuckerman, Kieffer & Knee, 1998). The obstacles may interfere with performance and this allows the person to discount responsibility for failure and to take credit for success.

Self-handicapping behaviours may emerge in students with a fixed mindset as they intentionally withhold their effort when confronted with a difficult task; for example, not studying sufficiently for a test or by leaving things to the last moment. To be confronted with a difficult task for which high effort is needed poses a conflict for students with a fixed mindset pursuing performance goals; high effort may be necessary for success on the task, but high effort will for them mean low-ability (Dweck, 2000).

As Covington and Omelich (1979) point out that “to try, or at least appear to try, but not too energetically and with excuses always handy… difficult to imagine a strategy better calculated to sabotage the pursuit of personal excellence” (p. 178).

Dweck (2000) comments that it is hard for students to “maintain confidence in their ability if every time a task requires effort, their intelligence is called into question” (p. 41). If a student withholds effort and does poorly, they can still think highly of their ability and preserve the belief that they could have done well had they applied themselves. If a student happens to do well anyway then this verifies their intelligence even more. The effect of self-handicapping
over time will be to lower student achievement as the vicious cycle of self-handicapping behaviours reinforces poor adjustment and vice versa.

Muenks and Miele (2017) suggest that situational clues are important determinants of how individuals think about effort and ability within a particular context. Their study showed that aspects of the situation whether task-involved, ego-involved, or emphasising or de-emphasising social comparisons can influence an individual’s perception of the relation between levels of effort and ability. They propose that individuals can quickly shift between thinking of effort and ability as being inversely related versus positively related. According to Tempelaar, Rienties, Giesbers and Gijselaers (2015), effort beliefs play a pivotal role as mediators of relationships between implicit theories of intelligence and achievement goals. They argue that the self-perception of students on the role effort plays in learning is crucially important for academic success. In this study, how students define effort and intelligence and the emphasis they give to the role of effort and intelligence in academic achievement would help to clarify their mindset in particular school subject domains and contexts.

**The affective domain.**

The benefits of a growth mindset also extend to the affective domain. College students with a growth mindset showed increased self-esteem over the academic year (Robins & Pals, 2002). King, McNerney and Watkins (2012) argue that how you think about your intelligence determines how you feel in school. They found that students who think their intelligence is fixed are more likely to feel negative emotions such as anger, anxiety, shame, hopelessness and boredom. Tuckwiller and Dardick (2018) in their university study of 245 students, found that students with anxiety and/or depression demonstrated significantly more fixed mindsets and higher levels of pessimism. According to King (2012), students who view intelligence as more malleable have higher levels of well-being and better adjustment outcomes. Furthering his research on mindset and subjective well-being, King (2017) posits that “positive emotions broaden people’s mindsets and expands their thought-action repertoires” (p. 143). In a study of 273 secondary students in Singapore, researchers, Luo et al. (2014) investigated the relationships of students’ incremental beliefs of mathematics’ ability to their achievement emotions, such as enjoyment, pride, boredom, anxiety, classroom engagement (attention and disruption) and achievement. In their analysis of incremental beliefs of mathematics’ ability,
it was found to be associated positively with mathematics enjoyment and pride and negatively with mathematics boredom and anxiety. These achievement emotions mediated the relationships of incremental beliefs of mathematics ability to classroom engagement and mathematics achievement. Zeng, Hou and Peng (2016) in their study of 1260 students from primary to middle school in China, reported higher levels of growth mindset predicted higher psychological well-being and school engagement through the enhancement of resilience. Schleider and Weisz (2016) analysis of mental health problems across an academic year for fifty nine, early adolescents aged 11 to 14, suggested that a fixed mindset was more strongly associated with mental health problems in girls than in boys. Schleider and Weisz (2016) concluded that compounded factors such as “differences in adult feedback, exposure and reactivity to interpersonal stress, perceived mastery and coping strategies may be different for girls” (p. 134).

The theory of mindset provides a valuable framework for understanding student motivation and related learning behaviours. Schunk (1995) comments that “with respect to the achievement domain... students have fundamentally different beliefs about their capabilities for learning and developing skills” (p. 312). Martin (2015a) suggests that growth approaches to student development is a potentially exciting direction for psycho-educational research and practice. Bostwick, Collie, Martin and Durksen (2017) urge there might be merit in targeting mindset and growth goals together in educational research. The empirical research to date has provided consistent evidence linking mindset to motivation; usually through one or more mediating variables (Kinas & Kurtz-Costes, 2007; Tempelaar, Rienties, Giesbers & Gijselaers, 2015). Much of the research to date has been quantitative in nature: it has used standardised measures of mindset and behaviours, via fixed-choice questionnaires. What is mainly absent in the research is the student voice in describing their implicit beliefs about intelligence and ability in mathematics in particular as it pertains to their future participation in the subject. This study provided opportunities for students to reflect on and speak about their implicit beliefs of intelligence and their learning behaviours in the natural school environment or ‘every day’.
The relationship between mindset and achievement.

The relationship between mindset and achievement will now be explored by examining correlational studies of growth mindset with academic achievement and the extensive intervention research that has been undertaken to raise achievement outcomes.

Correlational studies.

There is now a substantial body of research that provides evidence of links between students’ achievement and their beliefs about learning. A growth mindset has been linked to higher student achievement (Blackwell et al., 2007; Dweck, 2000; Good, Aronson & Inzlicht, 2003; Gonida, Kiosseoglu & Leondari, 2006). Romero, Master, Paunesku, Dweck and Gross (2014), after surveying 115 students through middle school and recording their grades and course selections, found that students who believed that intelligence could be developed earned higher grades and were more likely to progress to more advanced mathematics courses in the senior years. Boaler (2016) exploring the PISA (Program for International Student Assessment) data reported that the “highest achieving students in the world are those with a growth mindset, and they outrank the other students by the equivalence of a year or more of mathematics” (p. 7). In general, most researchers contend that mindset does not have a direct influence on achievement but is mediated by other variables that come into play, including the factors discussed in the previous section such as goal orientation, effort expenditure and persistence (Debacker Roedel & Schraw, 1995; Leondari & Gialamas, 2002; Dupeyrat & Marine, 2005). Basing their conclusions on a meta-analysis, Burnette, Boyle, VanEpps Pollack and Finkel (2013) proposed a mediation model that linked implicit theories to self-regulation and achievement by the goal-related behaviour that were used by students. These behaviours included goals setting (achievement goal orientations), goals operating (mastery versus helpless strategies) and goals monitoring (expectations of future success and negative emotions). According to Magno (2012); Blackwell et al. (2007) and Jones, Wilkins, Long and Wang (2012), when learners believe that their intelligence can be improved and their goal orientation is mastery-based, then higher achievement is possible. In their meta-analytic review of 46 studies involving 412,022 students, Costa and Faria (2018) reported a modest but positive direct association between students’ incremental (growth) theories of
intelligence and their academic achievement. Notably this association was stronger when measured in specific academic subject domains requiring verbal and quantitative skills.

Some researchers have focused on the academic challenges related to the transition from primary to secondary school. The transition from primary to secondary and intermediate to senior secondary can be a time when students’ motivation and achievement decline. The work gets harder, the grading becomes more stringent and the environment can become less personalized and nurturing (Dweck, 2008). Previous research (Hong et al., 1999) has revealed a relatively long term negative effect of a fixed mindset on achievement as students advance in school, whereas students with a growth mindset are more likely to take remedial action if performance was unsatisfactory and increase their effort accordingly. Tarbetsky et al. (2016) found that implicit beliefs are a “salient factor to consider when understanding Indigenous (Aboriginal) Australian students’ achievementas incremental beliefs positively predicted academic achievement” (p. 9). Preliminary evidence from California’s core districts in the U.S.A. (West, 2016), reported that scales used to measure student skills such as self-management, growth mindset, self-efficacy and social awareness were positively correlated with the key indicators of academic performance and behaviours both across and within the nine district schools that collectively served over one million students.

According to Claro, Paunesku and Dweck (2016), “students who have a growth mindset tend to earn better grades than students who hold a fixed mindset, especially in the face of difficulty” (p. 8664). In their study, all 10th grade public students in Chile completed a shortened version of the standardised mindset questionnaire (Dweck, 2000), about the malleability of intelligence while the Chilean government also administers standardised tests to measure mathematics and language skills to this grade every year. Claro et al. (2016) reported a strong positive relationship between student’s beliefs about intelligence and their academic performance in mathematics and language across all Chile’s schools and across all levels of family income. These national level correlations were complemented by multiple prior randomised field experiments indicating that growth mindset has a causal impact on achievement. The researchers found that students from the lowest socio-economic status (SES) families were twice as likely to endorse a fixed mindset as students from the highest SES families and schools. Most importantly students who had a growth mindset but were from low-income families showed comparable test results with fixed mindset students of higher
income families. Claro et al. (2016) suggest that a “growth mindset may help mitigate the negative effects of economic deprivation on academic achievement” (p. 8667). The psychological implications of this study in terms of mindset provides new understandings of how economic disadvantage may lead to academic underachievement.

**Intervention studies related to mindset, short and long term outcomes.**

This section reviews the research literature on intervention studies related to mindset. The research studies will be discussed in terms of short and long term interventions. Recent research has highlighted that mindset is, at least to some extent, malleable. Intervention programs have been able to encourage a growth mindset in participating students, which in turn has led to higher levels of achievement. Chen and Tutwiler (2017) refer to growth mindset intervention as an “inoculation” against negative motivational and achievement outcomes (p. 127). Aucock, Merino and Wilmot (2017) believe that teaching people about “self-theories in relation to the brain’s malleability can help them to change the mindset that they hold and thus how they respond to challenges and setbacks” (p. 387).

Theories of intelligence can be manipulated by the researcher priming the participants by intervening in their learning. Intervention protocols for example may consist of the participants reading articles, viewing slides or videos, having special lessons or instruction, online tutorials, being involved in discussions, role playing and letter writing. The interventions can take many forms and the outcomes are usually compared to a control group that has not experienced the intervention. Intervention studies can be considered quasi-experimental and provide useful evidence for the relationship between growth mindset and changes in academic motivation and achievement.

**Short term interventions.**

Short term interventions usually consist of ‘one shot’ single delivery interventions with the results recorded in a short time frame. Some interventions have shown that exposing students to convincing data about the value of either a fixed or growth mindset can have an effect on their subsequent effort on a task. The following seven studies illustrate the relative success of short term interventions however more research is required to ascertain whether these interventions must be continually repeated to have lasting effects on achievement.
Hong et al. (1999) primed mindsets by having participants read a *Psychology Today* type article that compellingly presented either an entity or an incremental theory supported by extensive research. Students who had been primed with a malleable or incremental view of intelligence were more likely to work on a remedial task after failure feedback than those primed with an entity or fixed view of intelligence. This research suggests that theory priming leads participants to act in a similar manner to those who actually have these beliefs.

Park, Rosenberg-Kima, Rosenberg, Gordon and Breazeal (2017) investigated the effect of a peer-like social robot – ‘Tega’, on children’s mindset. The robot was able to engage in taking turns in solving a puzzle with a child while offering encouragement. The children solved tangram puzzles and depending on which condition the robot’s behaviour differed. Before interaction with the robot there was no significant difference in the children’s mindset, however the children’s growth mindset increased after the interaction with the peer-like robot with a growth mindset and the children showed more resilience to failure over time.

In a study with 15,000 children, video games have been utilised to encourage the development of growth mindset behaviours (O’Rourke, Haimovitz, Ballwebber, Dweck & Popovic, 2014). Using a “brain points” incentive structure, the system showed children how to practise and achieve growth mindset behaviours and taught them the theory underlying this mindset. The growth mindset intervention increased persistence, however, a drawback to the study was that children were only exposed to the intervention for three minutes on average, yet with significant small positive effects.

In order to improve academic outcomes of rural adolescent girls, Burnette, Russell, Hoyt, Orvidas and Widman (2017), utilised an online growth mindset intervention titled ‘Project Growing Minds’. The mindset intervention group reported stronger growth mindsets than the control group and this effect held at the four month follow-up with reports also of increased learning motivation and higher end of semester grades. The intervention however did not have a significant total effect on academic attitudes or final grades compared to the control group.

Utilising materials from Blackwell et al. (2007) as the focus of a one-shot growth mindset intervention (55 minutes) and modelled on the procedures used by Yeager et al. (2013), Defacer, Heddy, Kershan, Crowson, Looney and Goldman (2018) influenced ninth graders’
implicit beliefs about intelligence and related achievement goals at two different schools. The researchers described their results as ‘modest’ indicating that one shot interventions can promote an intelligence growth mindset. Unfortunately academic achievement was not directly measured in this study.

To increase first year Norwegian high school students’ perseverance in mathematics, Bettinger, Ludvigsen, Rege, Solli and Yeager (2018) developed a computer program with three online sessions each lasting 45 minutes. All students had to solve a series of algebra questions at the end of the intervention/placebo treatment. As has been noted before in intervention studies the experimental effect of the intervention was significant only for students who previously had a fixed mindset or had low achievement prior to the intervention.

The implications of intervention research for education will be discussed at the end of this section. In general, the results of these studies show a variety of promising methods to encourage growth mindsets and improve academic outcomes. The interventions provide evidence that students’ implicit theories of intelligence can be changed at least temporarily through contrived and compelling messages but the long term effects of short term intervention training needs to be assessed. Reasons for the differential effects of interventions for individual students also needs to be examined.

**Longer term interventions.**

Longer term interventions have provided compelling evidence for the malleability of mindset, and the relationship between students’ growth mindset and academic achievement. Longer term interventions consist of programs which are delivered over several weeks or months. The purpose of presenting the next sixteen studies is to demonstrate the current research enthusiasm for growth mindset interventions albeit with some significant and some mixed results. The studies range from primary through to secondary school, mathematics related university courses, the influence of mothers’ growth mindset training on their child; the use of mindset interventions to lower stereotype threat in mathematics and the need to upscale interventions to meet large student numbers. Warnings have also been given in the research literature that mindset interventions “can seem magical” (Walton, 2014, p. 76; Yeager & Walton, 2011) but the reality is that interventions must be based on wise theories of psychological processes that unfold over time.
In two studies with seventh grade secondary students, Blackwell et al. (2007) showed that a growth mindset had beneficial consequences for student achievement. In their first study, students with a belief that intelligence was malleable improved in their grades over the two years of junior high school. In their second study, the purpose of the intervention was to teach an incremental theory to half of the students (experimental) and not to the other half (control). The researchers then assessed the effects on classroom motivation and achievement. A positive change in classroom motivation was promoted in the incremental theory experimental group compared with the control group. Overtime, students in the control group displayed a continuing decrease in grade achievement, while this decline was reversed for students in the experimental group.

Blackwell et al. (2007) developed a motivational model of achievement that specified the process through which students’ beliefs about the changeability of intelligence and achievement goals are related to their academic grades. They demonstrated that students with a growth mindset were more committed to mastery goals and were more likely to believe that their effort was necessary and effective in achievement compared with students with a fixed mindset. These students with mastery goals and effort beliefs were more likely to report making less ability-based, helpless attributions when faced with setbacks and more likely to cite using positive strategies. Consequently these students showed an improvement in mathematics grades in junior high school.

A further longer term intervention, using an online interactive program *Brainology* showed promise with participants in the short term (Donohue, Topping & Hannah, 2012). The *Brainology* program was designed to promote the use of a growth mindset approach in schools (Mindset Works Inc., 2008). The program led to a significant increase in pre- to post-mindset scores for the intervention group who had experienced *Brainology*. However, there was a significant decline at follow-up and the initial impact of the intervention was not sustained. The study was limited by the small sample size and it raises questions about the long-term effectiveness of some mindset interventions.

Esparza, Shumow and Schmidt (2014) compared the mindset beliefs of gifted Year 7 students. The *Brainology* intervention consisted of the online software program. Students participated in the interactive program for six weeks. The gifted students who participated in the
intervention increased in growth mindset. There was a lasting effect of the intervention as this increase in growth mindset was maintained over time.

Continuing this research into mindset interventions, Schmidt, Shumow and Kackar-Cam (2017), in a quasi-experimental study, over a six week period, with seventh and ninth grade students also utilised the Brainology mindset intervention. Compared to the control groups, the ninth grade intervention groups showed increased control of their learning and interest and maintenance of their skills to address and tackle academic challenges. Similar effects were not found for the seventh grade intervention groups in learning and interest. The Brainology program was more effective at influencing global mindset related beliefs for the ninth graders relative to the seventh graders which may reflect optimal developmental periods of mindset intervention.

In order to deliver psychological interventions at key educational points in a student’s learning journey, Banerjee, Bryck and Grabowski (2016) pinpointed rising high school juniors and seniors as a prime audience for a mindset intervention in their High School Summer Program (HSSP). Due to the nature of the HSSP curriculum both control and experimental groups shifted their attitude towards a growth mindset and the mindset intervention group compared to the control group showed improvement in their beliefs about hard work, constructive criticism and academic attitudes.

Kurtz-Costes, McCall, Ki law, Wiesen and Joyner (2005) lamented that as children get older they tend to associate intelligence with knowledge acquisition rather than problem solving, the former emphasised in schools probably by testing regimes. A thinking skills intervention on children’s concepts of intelligence (Burke & Williams, 2012) was a unique study in that the intervention explicitly taught thinking skills to foster incremental concepts of intelligence rather than knowledge acquisition. Prior to the intervention, the majority of children held fixed beliefs about intelligence. After the intervention, children in the experimental conditions moved towards ‘borderline incremental views of intelligence’ but children in the collaborative learning condition demonstrated strong incremental views of intelligence. The researchers argued that interventions that promote an understanding of thinking skills and the nature of intelligence are most likely to be productive.
An Intensified Algebra program (IA) was to enable mathematically underprepared students to successfully complete Algebra 1 in the ninth grade (Martinez, Bragelman & Stoelinga, 2016). Algebra was chosen as it is considered to be a gatekeeper for the understanding of more advanced mathematics. A set of social-motivational tools was integrated into the program (Academic Youth Development, known as the AYD program) teaching students the theories of malleable intelligence, strategies for goal setting, effective effort, how to learn and effective communication strategies and applying them to mathematics. The results showed that AYD students’ performance significantly increased over the academic year in algebra proficiency enabling them to catch up with their peers toward more advanced mathematics courses.

Mindset interventions have been used to help students complete difficult university courses. Cutts, Cutts, Draper, O’Donnell and Saffrey (2010) used the theory of mindset to explore and mitigate the high drop-out rates in an introductory university computer programming course. The researchers hypothesised that the high drop-out rates may occur because students adopt a fixed mindset towards programming and so give up when met with severe challenges. When manipulating mindset to positively influence introductory programming performance, they found that the mixture of teaching mindsets and giving mindset messages on returned assessment tasks resulted in a significant change in mindset and a corresponding significant improvement in test scores.

When exploring changes in computer science students’ implicit theories of intelligence across the semester, Flanigan, Peteranetz, Shell and Soh (2015) noted that implicit theories were not as stable as reported in previous research literature. They found that students’ incremental or growth mindset decreased from the beginning until the end of the semester, particularly as the course became more challenging. The researchers suggest that perhaps what was needed were intervention programs to help students sustain their belief in their intelligence as a malleable trait within one’s control, and not to lose faith as their outcomes did not match their effort. The possible lack of stability for the growth mindset as noted in Flanigan et al. (2015) raises further questions related to the authenticity of student growth mindset at the commencement of the computer science course.

A training program aimed at parents rather than students was conducted by Hadipoor, Jomehri and Ahadi (2015), with mothers of preschoolers on growth mindset over a period of
six weeks. They concluded that training mothers in the growth mindset can increase their child’s level of competence motivation, attention/ perseverance (at least three months after training), and total learning behaviours. This intervention is important as it reflects the influence of parents, in this case the mother, on the development of a child’s mindset.

Stereotype threat.

Stereotype threat, according to Huguet and Régnier (2009), refers to a “decrease in test performance in situations where individuals feel threatened by the possibility that their performance will confirm – to others and/or themselves – a negative stereotype about their group abilities” (p. 1024). Successful interventions have been conducted in secondary schools and colleges in the U.S.A. with students of varying socioeconomic, ethnic and cultural backgrounds. Aronson, Fried and Good (2002) in a study with 109 African American and White College undergraduates, set up a treatment group with a malleable or incremental intelligence emphasis and pen pal who affirmed the message; a control group without malleable intelligence emphasis with pen pal and a group with no pen pal and no malleable emphasis. The students within each ethnic background were randomly assigned to each group. The experimental groups reported greater academic engagement and obtained higher grade point averages than their counterparts in the two control groups. This study was followed by another incremental theory intervention with 138 seventh-grade students both male and female, of Hispanic, Black and White race, in a rural school district in Texas (Good, Aronson & Inzlicht, 2003). Students in the experimental conditions were mentored by college students who encouraged them either to view intelligence as malleable or to attribute academic difficulties in the seventh grade to the novelty of the educational setting. Females in both experimental conditions earned significantly higher mathematics standardised test scores than females in the control condition. This finding has important implications for female participation in STEM subjects as higher mathematics achievement in high school may encourage females to participate and persist in university mathematics courses. Black and Hispanic students and low-income adolescents in the experimental conditions also earned significantly higher reading standardised test scores than students in the control condition.

Zonnefeld (2016) studying the effects of growth mindset training on undergraduate statistics students utilised four, 15 minute growth mindset training sessions over the course of a
semester to help students understand how the brain functions biologically with a focus on the malleability of intelligence. Post tests showed that females increased mastery of statistical concepts at a statistically significant greater rate than males after these interventions. The increased mastery by females may be due to the effect of growth mindset training reducing the possible stereotype threat experienced in the statistics course particularly as they came to understand how intelligence develops.

Scaling up of interventions.

As interventions may be costly and meet the needs of a small number of students, researchers have therefore been keen to study how whole year groups or schools may receive mindset training. Interventions can be scaled up to benefit a greater number of students and at a reasonable cost. Paunesku, Walton, Romero, Smith, Yeager and Dweck (2015) worked on mind-set interventions as a scalable treatment for academic underachievement. In the U.S.A., 1,594 students in 13 geographically diverse high schools were randomly assigned to the control condition or one of three intervention conditions; a growth mindset group, a sense of purpose group, or the group with the two interventions combined. There were two online 45 minute sessions, two weeks apart. Student mindset was measured at the start of Session One and the end of Session Two. The achievement was raised in a large and diverse group of underperforming students over an academic semester, however the interventions were not significant in raising academic achievement of the students not at risk of dropping out of school. Perhaps this latter group had no need of the intervention. Students who received both interventions did not show greater benefits. This may be because interventions introduced at the same time did not have cumulative effects. This study highlighted the fact that mindsets matter most when students encounter challenges in school.

Further to their research, Yeager, Romero, Paunesku, Hulleman (2016) combined theoretical expertise with a design-based approach in a study with ninth graders transitioning to high school across the U.S.A. This was undertaken in order to acquire insights about the barriers to students’ adoption of a growth mindset without waiting for a full scale, long-term evaluation. The revised intervention was more effective in changing beliefs and short-term behaviours than materials used in previous studies. Also, quite importantly the intervention improved core course grades for previously low achieving students.
Growing out of a concern that many students lacked the belief that they could learn and using an improvement science approach to design and scale up a social psychological intervention, Barron, Hulleman, Hartka and Inouye (2017) demonstrated the use of a ‘Growth Mindset App’ to teach middle school students about adopting a growth mindset. The use of an application may be appealing to adolescents and more likely to be utilised. Students exposed to the application increased their growth mindset and outperformed their classmates who were not exposed to the app, on both short and long term academic performance outcomes.

**Summary of the Intervention Research.**

The studies which were discussed demonstrate that the theory and empirical findings related to mindset, provide a powerful tool for understanding the issues related to student motivation and achievement. Mindset matters most when students encounter challenge in school. Some evidence suggests that the ability level of participants may lead to differences in reactions to mindset interventions. Malleability interventions may be more useful for those who have sufficient ‘room to grow’ in their abilities than those who are already strong in their abilities (Burns & Isbell, 2007; Schwartz, Cheng, Salehi & Wieman, 2016). Students’ implicit theories of intelligence can be changed at least temporarily through contrived and compelling messages. Blackwell et al. (2007) provide substantial evidence that mindsets may be alterable in the long term with consequent long term effects on achievement. It is thought that growth mindset interventions work by reducing performance anxiety and maladaptive responses to failure by emphasising the importance of effort (Spitzer & Aronson, 2015). Interventions may be more effective when students are at an optimal level or readiness for training. Teachers promoting an understanding of thinking skills, the nature of intelligence and brain plasticity (brain science) may be more productive in developing students’ growth mindset.

More research is needed as interventions do not always work as planned. Yeager, Walton and Cohen (2013) point out that interventions are not ‘magic’ and will affect long-term outcomes only if they target students’ subjective experiences in school by conveying persuasive psychological ideas, and most importantly tap into critical recursive processes. Two meta-analyses conducted by Sisk, Burgoyne, Sun, Butler and MacNamara (2018), reported weak effect sizes for the relationship between mind-set and academic achievement and mindset interventions on academic achievement. Hattie (2017) suggests that meta-analyses of growth
mindset intervention studies may show low effect sizes due to the sheer complexity of changing long developed coping strategies to failure, mistakes and challenge. Sisk et al.’s results, however, did support claims that “academically high risk students and economically disadvantaged students may benefit from growth mindset interventions” (p. 20). Schwartz et al. (2016) in their study found that the lowest achieving students after intervention did not change their mindset but did show achievement gains whereas the opposite was true for the high achieving students. The researchers claimed that broad based interventions which are not tailored to a specific segment of the student population, may be ineffective for a large proportion of students, for example; growth mindset interventions may be taken up differently by higher and lower achieving students. The following quote highlights the complexity of mindset. Schwartz et al. (2016) hypothesise that:

The higher achieving students being good at school learned what answers they should give to a mindset survey, but they treated the message of the intervention as just another thing to learn in school. In contrast, the lowest achieving students found a message of possible change compelling, and while they did not change their beliefs about intelligence, they did feel a boost of optimism that drove them forward. (p. 400)

How we think about gaps in school achievement does matter. Spitzer and Aronson (2015) encouraged the view that achievement gaps are partly about the structure of the learning environment and about the subjective experience of that structure. Small changes to students’ perceptions of how they think about themselves and others can spur cascading results in achievement. Interventions work subtly but may produce a positive spiral that is self-reinforcing. Contextual details may also matter and have an effect. Student’s educational experiences depend on details of the social context, for example, how tasks are framed, how the task is administered, who else is in the room. We need to know the conditions that optimally invoke the strategies of growth. DeBacker et al. (2018) suggest that perhaps even subtle changes in intervention delivery, social context or the individual differences among participants may influence the efficacy of replication” (p. 18).

Farrington, Roderick, Allensworth, Nagaoka, Keyes, Johnson and Beechum (2012), note that “psycho-social interventions aim to change student perceptions and interpretations of the school and classroom context rather than changing the context itself” (p. 35). Growth mindset
training, as long as it is specifically tailored, is a promising method to address the underrepresentation of females in mathematics and other STEM related fields.

Conclusions from research on mindset, motivation and achievement.

There is a significant body of evidence demonstrating that a growth mindset is linked to higher levels of academic achievement. There is further considerable research showing that mindset is malleable to some extent. These two findings highlight the profound importance of a growth mindset for students’ motivation and achievement.

As discussed earlier, most of the previous studies have been quantitative in nature and have relied solely on fixed choice questionnaires, indeed many have been conducted in a laboratory type setting, using “single-shot” interventions. Quihuis, Bempechat, Jimenez and Boulay (2002) argue that the exclusive use of questionnaires/surveys to assess children’s notions of their own intelligence deprives us of the opportunity to capitalise on what they perceive as their own intellectual strengths and weaknesses. Overall these studies lack the ecological validity of a naturalistic study. A qualitative approach, which allows the students to explain their views in some detail and within the context of their everyday school life, is also lacking in the research. This gap in the research literature was addressed by this study as it sought a detailed and more nuanced understanding of mindset and how it impacts on a student’s motivation and achievement.

Factors which Influence Mindset

The preceding discussion presents compelling evidence for the positive effects of a growth mindset for student achievement. This research also indicates that mindset can be modified, at least in the short term, with an increase in growth mindset leading to significantly increased achievement. Further important questions arise from this work: why do some students have growth mindsets while others have relatively fixed beliefs? What factors influence the development and maintenance of mindsets?

Research suggests that implicit beliefs or assumptions about intelligence are transferred from an early age to children by parents, teachers and the media (van Tuijl & van der Molen, 2015) and national and institutional cultures shape individuals’ beliefs about intelligence (Jackson
& Nyström, 2014). Schools represent a particularly important context for the development of mindset (Eccles & Roeser, 2011). The relationship between student beliefs and societal influences is significant, according to Morge (2005), especially as students consider future courses and careers. While research to date on these questions is relatively limited compared to the research on the effects of mindset, some valuable insights can be gleaned from sociological and psychological research. Sullivan, Tobias and McDonough (2006) point out that classroom culture may be an important determinant of students not engaging in mathematics. Parents and teachers act as role models and transmit their expressed values to adolescents (Frenzel, Goetz, Pekrun & Watt, 2010). Gregory and Weinstein (2004) note the “perceived qualities of adult relationships in both home and school were linked with achievement in mathematics” (p. 422). Surprisingly, there is relatively little research on the relationship between school-related factors and their effect on student mindset. There has been some research on teachers’ use of feedback and the effects of peer culture and this will be reviewed in the following section. Studies which have investigated teachers’ and parents’ use of praise will also be discussed and finally seminal experimental studies by Mueller and Dweck (1998) and Kammins and Dweck (1999), on the effects of praise will be reviewed. The research relating to factors that influence mindset, discussed above, helps to understand the development of mindset of students in Australian school settings.

The role of culture.

There are divisive and deeply-held cultural beliefs which underpin learning and about what it means to be intelligent or smart (Boaler, 2013). According to Sternberg and Grigorenko (2004), intelligence is always displayed in a cultural context. Li (2005) argues that “traditional research on human learning has neglected people’s beliefs about learning, the role of culture in shaping these beliefs, and people’s consequent learning behaviour” (p. 190). A cross-cultural exploration highlights these difference in beliefs about the roles of effort and ability and the philosophies that underpin them.

East and west.

Most cross-cultural studies of values and beliefs regarding the role of intelligence and effort have been comparisons of Eastern (particularly Asian countries) and Western countries
(mainly the United States). International studies have consistently pointed to comparatively higher levels of educational performance in the Pacific Rim and Eastern Europe (Elliott & Phuong-Mai, 2008). Some authors have argued that the greater achievement that characterizes students from Asian cultures may be due to a greater belief in malleable intelligence and the importance of effort (Dweck et al. 1995; Jose & Bellamy, 2012; Tan, McInerney, Liem & Tan, 2008; Stevenson, Chen & Lee, 1993; Watkins, 2008; Yeung & Yeung, 2008).

Aditomo (2015) points out that the notion of intelligence may contain culture-specific dimensions. In the Confucian and Taoist tradition, intelligence is associated with knowledge and wisdom, in other words, an intelligent person is one who is capable of making wise moral judgments. In the Taiwanese tradition, intelligence is associated with cognitive ability and also inter-personal and intra-personal skills as well as self-effacement. In the Indonesian context studies have found that intelligence is characterised by cognitive ability and personality attributes such as hardworking, diligence, and being practical as well as achievements. In short argues Aditomo (2015), the non-Western term “intelligence” encompasses a broader set of attributes than the Western notion (p. 205).

In response to the question “can everyone become highly intelligent”? Rattan, Good and Dweck (2012) found that there were cultural differences in beliefs about the universal potential for intelligence. Their studies showed that in the U.S.A. context, people tended to believe that only some people have the potential to become highly intelligent whereas in the South Asian Indian contexts, people tended to believe that most people have the potential to become highly intelligent.

Arguably Western culture has a profound ambivalence regarding academic effort, and this is linked to cultural beliefs about the respective roles of intelligence and effort in achievement (Wu, 2005). Effort has sometimes been seen as being compensatory for talent or natural ability. In Western society, natural talent is often lauded over hard work or effort (Helding, 2011; Mercer, 2012). The ‘effortless achiever’ identity seems to be an attractive one in Western cultures. Jackson and Nyström (2014), point out that effortless achievement in certain discourses may be “heralded as the pinnacle of success, the epitome of true talent and a mark of genius” (p. 1). The authors engaged in discourses about effort and
‘effortlessness’ in Swedish and English secondary schools, which will be discussed further in the mathematics, mindset and gender section.

Western societies have often promoted and admired ‘natural’ talent. Western education is rooted in the Platonic tradition that emphasises nature (that is, innate abilities) whereas Chinese educational theories and practice have their roots in the Confucian tradition that emphasises nurture (Mok, Kennedy & Moore, 2011). In the Confucian tradition, students are blamed if they do not work hard (Wu, 2005). Effort and ability are intrinsically linked for the Chinese student. Salami and Hau (1994) put this succinctly, “for Chinese students, people working hard have higher ability and those who have high ability must have worked hard” (p. 233). This is in distinct contrast to the prevailing Western view that a person who needs to work hard must somehow not have ability or talent. Importantly, children may have two different beliefs in the relationship between effort and ability (Lam, Yim & Ng, 2008). One belief is that effort and ability are inversely related (the inverse rule), that is the less one’s ability, the more one has to make an effort for success. The other belief is that effort and ability are positively related (the positive rule), that is, the more one exerts effort, the higher one’s ability.

Chinese students’ learning and achievement has been of great interest to the research on implicit beliefs as traditionally it has been thought that Chinese parents and students emphasise the need for effort and generally believe that effort can compensate for lack of ability. Chinese proverbs emphasise the importance of effort. Such as:

With persistence, an iron pestle can be ground down to a needle.

Learning is like rowing upstream; not to advance is to drop back.

(Li, Zhou, Xiong, Nie & Fang, 2017, p. 5)

PISA 2012 results revealed that the top seven performing countries in mathematics were Shanghai - China, Singapore, Hong Kong – China, Chinese Taipei, Korea, Macao – China and Japan, in descending order of their scores (OECD, 2014). These Asian countries consistently emphasise the growth mindset, that intelligence is malleable and achievement is mainly a product of hard work, rather than inherited intelligence.
Stevenson et al. (1993) found that American students, as well as their parents, had a high regard for their own academic achievements. Tan et al. (2008) propose that because of the difference in emphasis, students educated in a Western country are likely to have a higher perception of their academic ability than Chinese students, who may have a higher effort goal orientation than Western students. Consistent with findings in Western societies, research by Chen and Wong (2014) suggests that Chinese students with stronger beliefs in a growth mindset were more likely to set mastery goals leading to productive learning behaviours such as positive strategies and planning with subsequent academic achievement. Chen and Wong’s study also found a positive association between performance approach goals and academic achievement in contrast to the results with Western samples. In other words, the results revealed that in Chinese students a stronger belief in an incremental belief of intelligence was associated with a greater tendency to adopt mastery and performance approach goals. This may be explained by the highly competitive and exam-oriented Chinese educational context with its emphasis on effort and performance.

As reported by Hsia and Xie (2014), Asian Americans’ show an academic advantage over white Americans. This gap is attributed to the cultural differences in beliefs regarding the connection between effort and achievement. Asian parents generally have high educational expectations, encouraging a strong work ethic in their children while fostering greater interdependence and collectivism within the family. Although the word mindset is not used by these researchers, the explanation presented is very similar to Dweck’s (2000, 2006) implicit beliefs or self-theories. Asian and Asian Americans tend to view cognitive abilities that can be developed or ‘grown’ through effort, whereas white Americans tend to view cognitive abilities as qualities that are inborn. Hsin and Xie (2014) suggest that Asian Americans may also benefit from the positive stereotype that portray them as “model minorities” who are destined to succeed (p. 8420).

Chinese-Australian children outperform their Australian peers in mathematics (Zhao & Singh, 2011). From their case study, it was found that Chinese-Australian students had high motivation for mathematics learning which was encouraged by their parents’ high expectations and high academic demand for their children. According to Zhao and Singh (2011), “Anglo-Australian parents value intrinsic motivation in learning mathematics, whereas Chinese-Australian parents value extrinsic motivation, seeing pressure as acceptable to
stimulating their children’s motivation to learn” (p. 83). Underlying their philosophy is that hard work produces high achievement and so Chinese-Australian parents monitor their children’s mathematics learning, purchasing extra mathematics curricula and supporting after school or Saturday morning coaching. In contrast Anglo-Australian parents are more likely to emphasise their child’s inner ability and desire to do well rather than personal effort. Pushing a child academically, particularly if the parents consider the child does not have ability is not considered to be acceptable.

Dahlin and Watkins (2000) noted that the Western student typically sees understanding as the operation of sudden insight, whereas the Chinese student typically thinks of understanding as a long process that requires considerable mental effort and memorisation aimed at deeper understanding through persistence and repetition. Thus, memorisation and understanding are seen as working together to produce quality outcomes. In the West, however, there is a separation of these two constructs, as memorising is often associated with ‘surface’ learning and understanding with ‘deep’ approaches to learning (Dahlin & Watkins, 2000, p. 65).

If Chinese students believe that understanding is a slow process requiring hard work, then the requirement of effort for academic success seems logical. However, if the Western view of understanding is believed to be a sudden, insightful process, then effort and persistence become less relevant. An important distinction highlighted by Wang and Ng (2012), is that Chinese students do not regard intelligence and school performance as tightly related but quite distinct entities. They found that Chinese secondary school students generally viewed intelligence as more unchangeable than school performance. They also found that viewing school performance as unchangeable uniquely predicts helplessness, above and beyond the effect of one’s belief about the changeability of intelligence.

Wang and Ng’s work highlights the importance of going beyond beliefs about intelligence per se in order to understand how those beliefs might relate to culture and impact on students’ learning and achievement. Their findings also point to the possibility of the same distinction in Australian students: do they also hold different beliefs about the malleability of intelligence and school performance? Mindset may not be as clear-cut as has been presented in earlier research as there may be many subtle distinctions in students’ implicit beliefs of intelligence.
Heine, Kitayama, Lehman, Takata, Ide, Leung and Matsumoto (2001) reported cultural differences in university students from Japan and North America in their responses to success and failure. They found that Japanese students had a self-improving orientation, in that after failing a task they persisted more on a follow up task than those who succeeded. In contrast, North American students who failed a task persisted less on a follow up task than those who succeeded. For the Japanese students failure highlighted where corrective efforts were needed. Heine et al. (2001) suggest that the two cultures want to do their best and share similar goals however they use different strategies to reach these goals such that “Japanese students work harder when focusing on their short-comings (self-criticism), whereas North American students work harder when focusing on their strengths (self-enhancement)” (p. 611).

Heine et al. (2001) explain these cultural differences in terms of implicit beliefs of intelligence. The Japanese students viewed performance on RAT (Remote Associates Test - a measure of creativity), to be due to incremental abilities more than the North Americans, thus persisting in the face of failure was a successful strategy. North American students viewed RAT more as a test of relatively fixed abilities, and so “continued persistence in the face of failure would be met with more failure and a threat to self-esteem” (p. 611). The Japanese students showed an emphasis on the process of learning and creating rather than product, whereas the North American students with their emphasis on self-esteem seemed to put more of an emphasis on product; the great things one could accomplish or what one could become through hard work and determination.

The previous discussion highlights the importance of cultural beliefs and traditions in the development of implicit beliefs about intelligence. “It is a recognition that culture and psyche make each other up” (Heine et al., 2001 p. 612) and illuminates important questions for further research.

School related factors.

Schools serve as an important developmental context for young people. Since children spend many hours in school, it is instrumental in their intellectual and social-emotional development (Eccles & Roeser, 2011). There has been relatively little research investigating school-related factors in the development of mindset. Differing teacher expectations of students based on
gender may influence a girl or boy’s mindset. School practices such as streaming (grading) and school setting may also influence student mindset. An investigation of other school-related factors, including Australian student peer culture regarding implicit beliefs about intelligence, and teachers’ feedback, is also valuable in understanding differences in the development of student mindset.

**Teachers and gender.**

In today’s schools student gender must still be taken into account when discussing factors that influence mindset. An individual’s gender acts as a stimulus that influences people’s responses to the person (Hyde, 2007). Stereotypes regarding gender differences continue to prevail, argues Riegle-Crumb and Humphries (2012), despite social movements, reforms and policy initiatives aimed at issues of equity. There are still strongly held cultural beliefs that men and women are innately and fundamentally different in skills and interests and these beliefs probably persist because “the idea that men and women are different is considered natural and not discriminatory” (Riegle-Crumb & Humphries, 2012, p. 291). Perceived gender identities have historically been used to explain both male and female achievement and male and female underachievement (Jones & Myhill, 2004). Beliefs about gender may inform teachers’ beliefs about learning potential.

A study of gender related beliefs of teachers in elementary school mathematics (Tiedemann, 2000) was investigated in schools in and around a North German city. The study revealed that teachers saw many of their boys in a different way than their girls. Their findings revealed differential beliefs for boys and girls in mathematics indicating perceptual bias. Teachers rated mathematics as more difficult for average-achieving girls than for equally achieving boys and thought that their average achieving girls were less logical that equally achieving boys. In regard to girls, teachers attributed unexpected failure more too low ability and less to lack of effort than with the boys. Girls, especially those of average or low achievement, were thought to have to exert more effort than boys to achieve a certain level of mathematical performance. This stereotypical bias could be more detrimental to girls’ achievement in mathematics than to boys, as it was noted in the study that teachers were aware of the girls’ lower self-concept of mathematical ability.
School-level practices.

The nature of the school and classroom context are critical to understanding changes in the motivation and engagement of adolescents (Ryan, 2001). Wang and Eccles (2012) note that students who feel socially supported by teachers are more likely to experience less anxiety in their learning and focus more on mastery goals. For many students, adolescence marks the beginning of a downward trend in motivation and achievement. High schools are more departmentalised than primary schools, as well as larger and more performance oriented, resulting in more social comparison grading standards. With more teachers and students in a high school, an individual student may have fewer opportunities to forge strong and positive relationships with school adults and other students (Wang & Eccles, 2012). This may prevent identification with the school and a lack of a sense of belonging. If students are provided fewer opportunities to feel competent in their school work, and if the results of their efforts are not rewarded by higher grades, then the valuing of learning may decrease and their mindset may become more fixed. Middleton, Kaplan and Midgley (2004) note that when students move from one learning environment to another, they “re-evaluate and reconstruct their goals and actions” (p. 293). Adaptive or maladaptive behaviours may be a consequence of their performance approach or performance-avoidance goals.

Boaler (2013) argues that schooling practices can be based upon notions of fixed ability, which limit students’ attainment and increases inequality. The research by Meece, Anderman and Anderman (2006) suggests that young people experience diminished motivation when the school environment focuses on demonstrating high ability and competing for grades. The grading or setting of classes has implications for students’ beliefs about their own potential change in response to the groups into which they are placed. Graded classes imply that ability to do school work is fixed, that somehow the work given to students is matched by some idea of unchangeable ability. Students who can be damaged by fixed ability beliefs are high achieving girls who in the primary years have been thought of as smart and clever (Dweck, 2006). When these girls are more challenged in high school they may infer that they are not smart after all and opt out of more demanding work. High-achieving girls may suffer from the idea that they are smart and need to maintain the image of smartness, leading to fear of challenge and inability to cope with failure (Boaler, 1997b). Fixed ability thinking is a major driving force in educational practice, argues R. Marks (2013), and particularly in mathematics.
education. R. Marks (2013) points out that graded classes are a form of “educational triage with many unintended consequences and deeply limiting impacts” (p. 32). Savani, Rattan and Dweck (2017) argue that people’s implicit theories about intellectual potential drive their positions on education. Further, Yorke and Knight (2004) note that the teacher is in a position of critical importance. Teachers need to know their own implicit beliefs about intelligence and how these beliefs could impact on students. Yorke and Knight argue that staff development needs to explore “the theories (often implicit) that teachers hold about their students and to make the case for an orientation towards malleability” (p. 33). A teacher with a fixed mindset may not be prepared to accept that most students can achieve to a high standard. In preparing students to take responsibility for their own learning, Carpenter and Pease (2013) advocate the development of growth mindsets to not only improve academic performance but also to contribute to the growth of non-curricular learning skills such as increased persistent behaviour.

Verniers and Martinot (2015) suggest that environmental cues conveyed in socialisation contexts may influence students own beliefs regarding the nature of intelligence. Vernier and Martinot’s study of 50 males and 35 female ninth grade students in France, examined whether secondary school students were knowledgeable about others’ beliefs and were asked to rate other males and females’ intelligence as malleable or fixed; whether other males and females made efforts for their current achievement and whether female or male students had potential for future success. The participants reported that others perceived boys’ intelligence as more malleable than girls’ intelligence and the more hardworking a female student was perceived to be in a school, the less she was considered to have potential to succeed in the future. In other words, the perception was that females had to work hard because they had less ability. If students have a fixed notion of intelligence then observing students as hardworking may indicate to them that the latter lack talent or intelligence. This link was not observed for male students. The study concluded that students were knowledgeable about unfavourable beliefs, shared in the school setting, regarding girls’ intelligence and potential. This may of course impact on girls’ own performance expectations and will have negative consequences on female students’ academic expectations. Unfortunately gender stereotypes may still permeate in contemporary high school classrooms. Laurel, Bornholt and Moller (2003) in their study of students in single sex and
coeducational schools also emphasised the importance of the social context for students’ attributions about achievement and intentions.

Attard, Ingram, Forgasz, Leder and Grootenboer (2016) point out the usefulness of the ecological perspective as developed by Bronfenbrenner (1979), in that it “places the child at the centre of the environment to explore the interactions between the child and various factors such as home, classroom, school and time” (p. 86). A study of mindset must take all these factors into account.

**Peer groups.**

After family, peer relations are perceived as the second most important source of social support affecting school adjustment (Lee, 2002). There is very little research to date that specifically examines the relationship between peer groups and mindset. Less is known about how the peer group influences motivation. Most research concerning socialisation in the peer group context was concerned with engagement and achievement in school, not motivation. Ryan (2000) notes that the term peer group has been defined as an “individual’s small, relatively intimate group of peers who interact on a regular basis often referred to as a clique” (p. 102). Ryan recognises three processes that are important in understanding socialisation in the peer group context: information exchange, modeling and reinforcement of peer norms and values. Modeling which refers to individual changes in cognition or behaviour that result from the observation of others can bring about changes in motivation and achievement. Ryan reports that children’s preference for challenge on a variety of tasks is influenced by exposure to a peer model’s preference for a challenge. As the taking on of challenging tasks is part of having a growth mindset, a students’ peer group may be potentially powerful in influencing mindset. Wang and Eccles (2012) suggest that adolescents develop confidence and competence in discussing different points of view and critiquing each other’s work.

Peer support may be especially important for adolescent girls in studying mathematics and science, posits Leaper, Farkas and Brown (2012), as an individual’s peer group may influence how she values and identifies with subjects. Kloosterman, Tassell, Ponniah and Essex (2008) found that both males and females in their secondary schools’ study recognised differences in the way boys and girls act and were treated in mathematics classes. For example, boys
caused more distractions while girls cared more about doing well. Perceptions of mathematics and gender were still an issue in the secondary setting.

Reis and McCoach (2000) reported that students seemed to resemble their friends more closely at the end of the year than they did at the beginning of the school year and noted that there was a correlation between a student’s achievement and the achievement of his or her closest peer group. It would be of interest to measure the intelligence mindsets of students in peer groups’ over the course of a year or two to see if their mindsets become more similar.

There has been some research highlighting the influence of peer culture on the development of school related values. Peer groups influence adolescent socialisation and identity by allowing young people to explore individual interests and uncertainties while retaining a sense of belonging and continuity within a group of friends. Becoming a member of a peer group is one of the primary development tasks of adolescence (Santor, Messervey & Kusumakar, 2000). Such groups give rise to peer cultures, which are the “stable set of activities or routines, artifacts, values, and concerns that children produce and share in interactions with peers” (Hamm, Farmer, Lambert & Gravelle, 2014, p. 216). Grade or year level can also function as a peer culture. Within each school exists a school-wide peer culture that comprises a relational and a behavioural component (Lynch, Lerner & Leventhal, 2013). The authors make the point that the relational describes the aggregate of students’ perceptions of the quality of peer relationships within a school, whereas the behavioural component is an aggregate representation of students’ actual behaviours in regard to academic tasks. Both components relate to academic outcomes. It would be expected that the mindset of the peer group to which one belongs will influence the whole group and their corresponding motivation and achievement. Broader cultural values concerning ability and effort play an important role in student peer group culture. Duong, Schwartz and McCarty (2014) found that students’ achievement values may be influenced by the ethnicity and gender of their peer groups. A student in a Western culture may believe that hard work is important to succeed academically, however there is often social pressure or peer pressure not to be seen to be trying too hard, so students may constrain their efforts or pretend they are not working hard. Duong et al. (2014) posit that popularity with peers and achievement may be fundamentally incompatible in American schools. This is a perspective that holds adolescent peer cultures devaluing achievement, with peers expressing disapproval when
students study, participate in class or engage with the school. Peer approval may be at risk if the individual shows excessive academic enthusiasm. Elliott and Phuong-Mai (2008) point out that students can be anxious not to be seen as nerds, as this may lead to unpopularity and harassment. It is not demonstrating high achievement so much as “displaying excessive interest or effort that is the problem for the motivated student” (p. 45).

Peers play a role in ethnic and gender differences in achievement, claims, Duong et al. (2014) in their study with Vietnamese-American and Mexican-American adolescents. Vietnamese students were more likely to admire and be friends with high achieving peers and academic and social skills were more strongly and positively linked for Vietnamese-Americans relative to Mexican-Americans and for girls relative to boys. Peer pressure to ‘not work hard’ according to Boehnke’s (2008) study, is less common in cultures with high achievement values, for example, in Asian countries such as China, Japan and Vietnam. He describes this relationship as follows:

The negative relationship between mathematical school performance and peer group pressure presumably is influenced by the culture-specific and by the individual strength of achievement values. In cultures where achievement values have a high average preference, the relationship between good academic performance and fear of social exclusion is presumably weaker than in cultures that put relatively little emphasis on achievement as a guiding principle in life. (Boehnke, 2008, p. 151)

Social network analysis was used to identify the peer groups of 331 seventh grade students from an urban middle school in the U.S.A. (Ryan, 2001). This study supported the contention that peer group context and influence is multi-faceted which in turn affects the development of young adolescents’ achievement beliefs and behaviours. The study found that young adolescent students tended to affiliate with other students who had academic characteristics similar to their own and the peer group influenced changes in students’ intrinsic value for school that is, whether they liked and enjoyed school. The peer group was not influential however with regard to changes in students’ utility value for school, that is, the usefulness and importance of school in their lives. Ryan (2001) notes that perhaps parents and teachers are more influential in this area and more importantly it indicates that peer groups are not equally influential on all academic characteristics.
Some recent research indicates that intervention programs can be successful in promoting productive peer cultures. The Supporting Early Adolescents’ Learning and Social Success intervention (SEALS) has been conducted in 36 rural schools in the U.S.A. Hamm et al. (2014) illustrate how teachers can make a difference in encouraging peer cultures to be supportive of effort and achievement. Involving 6th grade students and teachers, the study identified dimensions of the grade-peer culture amenable to change. The researchers then provided relevant professional development for teachers to create learning environments which supported more productive peer cultures for effort and achievement.

**Stage and grade differences in mindset.**

There have been very few empirical studies which have focused on differences in classroom or school environments across grades or stages of schooling. Implicit theories about intelligence might be expected to exert increasing influence as students move from junior to senior secondary education particularly when meeting increased challenges combined with increasing choices (Hong et al. 1999; Wang & Eccles, 2012).

According to Jones, Byrd and Lusk (2009), little is known about whether high school students believe that intelligence is malleable or fixed because most researchers have focused on younger children or adults. Ablard and Mills (1996) found that high school students believed intelligence to be more stable (fixed) than elementary students. Kurt-Costes et al. (2005) included eighth graders in their study finding that these students were less likely to report that intelligence was malleable than were younger children. Diseth, Meland and Breidablik (2013) also included eighth graders in their study finding less malleable implicit theories of intelligence compared to sixth graders in the elementary school. Martin (2015b) agreed that age has been found to be a significant negative predictor of implicit growth beliefs of intelligence. This has grave implications for secondary education and teachers.

**Role of praise.**

This section reviews the extensive research on teachers’ and parents’ use of praise and its subsequent effect on mindset.
Use of praise and feedback by teachers.

A series of seminal experimental studies by Mueller and Dweck (1998), demonstrated that a growth mindset can be cultivated by praising students for their learning process and not for their intelligence. The authors studied the effect of praise on students in a sample of 400 fifth grade students from several schools. Praise for ability had commonly been considered to have beneficial effects on motivation however these experiments showed how the type of praise has differential effects.

Mueller and Dweck’s six experimental studies demonstrated that praise for intelligence and praise for hard work had differential effects on children’s achievement. Teacher praise for intelligence had more negative consequences for students’ achievement motivation than praise for effort. Praise for intelligence “seemed to teach children to value performance, whereas praise for hard work led children to value learning opportunities” (p. 48). Kamins and Dweck (1999) furthered this study by testing the hypothesis that both criticism and praise that conveyed person or trait judgments could send a message of contingent self-worth in which children feel their worth is contingent on their behaviour or performance. The two studies involved kindergarten children (five to six years of age), who after participating in role-play tasks were provided with feedback of either person, outcome or process criticism in the first study and person, outcome or process praise in the second. Children displayed significantly more “helpless” responses on measures of self-assessment, affect and persistence after person criticism or praise than after process criticism or praise. The importance of these findings for teachers is that at these early ages, children can begin to develop self-beliefs or mindset about their own intelligence.

Teachers may provide different types of praise and feedback to girls and boys (Dweck, Davidson, Nelson & Enna, 1978; Gunderson, Gripshover, Romero, Dweck, Goldin-Meadow & Levine, 2013) which may have important consequences for the development of mindset. In an early study with fourth and fifth grade students, Dweck et al. (1978) found that teachers gave different feedback to boys and girls. For boys, more than 90% of all positive feedback was addressed to the intellectual quality of their performance; for girls, less than 80% referred to the intellectual quality of their work. Almost 20% of positive evaluation girls received for their work was for non-intellectual aspects such as neatness. The gender differences for
negative evaluation were more pronounced. For boys, about 50% of work-related criticism referred to intellectual inadequacy, the remaining criticism was for disobeying rules. In contrast, 90% of work-related criticism to girls was addressed to intellectual performance. There was little criticism of rule violation. Dweck et al. (1978) point out that the pattern of evaluative feedback given to boys and girls in the classroom can directly result in girls’ greater tendency to view failure feedback as indicative of their level of ability as the emphasis of criticism is on their intellectual performance.

Dweck (2000) also argues that giving children the label of “smart” or “gifted” does not prevent them from underperforming and in fact may lead to underachievement. Such labels may actually be the cause of self-handicapping behaviours such as choosing easier tasks or dropping out when faced with challenging problems or tasks. The positive praise that parents and teachers thought would increase self-esteem when they remark how clever, how intelligent a child is, may actually have deleterious consequences not originally foreseen.

Lam et al. (2008) conducted two studies to investigate how beliefs in the effort-ability relationship moderated the effects of effort praise on student motivation. In Study One, the participants were 28 seventh graders from a Hong Kong secondary school in a middle-lower class neighbourhood. The study was conducted in the students’ classroom thus increasing its ecological validity, however the studies were conducted by researchers, not their teachers. Their first study showed that effort praise could be motivational when the students believed in a positive relationship between effort and ability (positive rule) but could be demotivational when the recipients believed in an inverse relationship between effort and ability (inverse rule). The researchers emphasise that effort praise is not always motivational as it depends on the recipient’s beliefs in the relationship between effort and ability. Effort praise may be interpreted by the student to mean that the teacher thinks he/she has low ability. When students have a static or fixed perspective (mindset) and focus on the inverse relationship between effort and ability, then, they will be discouraged when they receive effort praise because high effort implies low ability. However, when students have a dynamic or growth perspective (mindset), focusing on the positive relationship between effort and ability, then they will be encouraged when they receive effort praise because high effort implies high ability.
In Study Two, the participants were 43 seventh graders from a Hong Kong secondary school in middle-lower class neighbourhood. The second study revealed that students who were primed to believe in the positive rule had more positive self-evaluation and higher motivation after effort praise than their contemporaries who were primed in the inverse rule. Lam et al. (2008) argue that when students believe that the high effort implies high ability, effort praise confirms their sense of competence and self-evaluation. These students will therefore find the given task interesting and are willing to do it again. However, when students believe that high effort implies low ability, they will be discouraged by effort praise. Effort praise becomes the cue for their incompetence and therefore students lose interest and confidence in doing the same task again (lose motivation). The studies would have been improved if the students’ implicit beliefs about ability and effort had been assessed prior to the reading of the priming comprehension exercise. The researchers would then have a base-line measure to assess whether the priming comprehension had changed the student’s implicit beliefs. The researchers conclude that high stakes testing for accountability and other external evaluations may produce a performance culture in our schools that promotes the inverse rule of effort-ability relationships among students. The emphasis in our schools needs to be encouraging students to focus on improving their own ability instead of comparing their ability with others, for example, self-referenced assessment and portfolio assessment. Lam et al. speculate that the positive rule is encouraged by learning-oriented contexts, whereas the inverse rule is encouraged by performance-oriented contexts.

Subtle linguistic cues can affect children’s motivation (Cimpian, Arce, Markham & Dweck, 2007). Person praise is generic connoting a stable trait of the child, while process praise is non-generic, focusing on one specific episode. Twenty-four preschool children were individually asked to act out several scenarios using puppets. In their study, the experimenters found that before children experienced any mistakes, there was no significant difference between the generic and non-generic praise conditions suggesting that the two types of praise were equally rewarding. On the post mistake measures, however, children who received generic praise showed significantly more helpless behaviour than children who received non-generic praise. Generic praise is defined as information more central to a category and implies that stable factors are associated with goal achievement, for example praising a child for being a good drawer in an art class. Subsequent mistakes reflect on this
ability and can therefore be demoralising. Non-generic praise is related to mastery motivation because it implies that success is related to effort, for example a child is praised for doing a good job drawing. Non-generic praise implies that non-stable factors are associated with goal achievement which suggests that failure can be changed.

The effects of the inconsistency of praise have been studied by Zentall and Morris (2010). In natural settings such as the school day, students are likely to hear a combination of both types of praise; generic praise and non-generic praise. Both of these types of praise have been linked to children’s conception of their ability and their achievement motivation (Cimpian et al., 2007). Zentall and Morris questioned whether the relative weights of each type of praise are different and whether hearing a small amount of one type might be more influential than hearing a small amount of the other type. The participants in the study were 135 kindergarteners recruited from two public schools in the Midwestern United States. The children were randomly assigned to one of five praise conditions in which consistency of praise type was varied. The researchers’ results replicated previous findings that non-generic praise promoted mastery behaviours and generic praise promoted helpless behaviours (Cimpian et al., 2007; Dweck, 2009; Mueller & Dweck, 1998; Kamins & Dweck, 1999). In addition, Zentall and Morris (2010) also found that the more non-generic praise children hear, the more likely children are to demonstrate positive self-evaluations, display mastery behaviours and persist after experiencing failure. One interesting finding was that inconsistent praise appeared to affect self-evaluation and persistence differently. The study’s results suggest that children may require only a small amount of non-generic praise to increase their positive self-evaluation but a majority of non-generic praise is necessary to increase persistence after failure.

The presented research raises the question as to whether no praise is good praise. Skipper and Douglas (2012) examined the effects of person and process praise with 145 school children aged nine to eleven years and 114 university students in the United Kingdom. As part of these studies, a control group was created where no verbal praise was given but only objective outcome feedback. Students in the process condition did not differ significantly from those in the control group however after one failure, students who received person praise reacted most negatively on all measures of performance, affect and persistence. Skipper and Douglas conclude that process feedback may not necessarily be positive, however
person praise seems detrimental to performance and persistence. It would have been interesting if the implicit beliefs of intelligence of the participants had been assessed both before and after the studies had taken place to determine the effect of praise versus no praise on these beliefs.

Maclellan (2005) emphasises that as our student populations are becomingly increasingly diverse, the motivation of students in a social-cognitive perspective is a dynamic, context sensitive and changeable construct. In motivating students, the teacher is not well served by relying on simplistic and common understandings of the construct of praise. She points out that:

> Effective applications of praise are mediated by students’ goal orientations, which of themselves may be either additive or interactive composites of different objectives and different contexts. (Maclellan, 2005, p. 194)

**Use of praise by parents.**

The use of praise is relevant to this particular study as there is a growing body of evidence that the type of praise that parents use is a significant factor influencing children’s mindset. These implicit beliefs or mindsets which develop at an early age are influenced primarily by parents/families, followed by teachers and schools. Dweck (2007) suggests that person-oriented praise versus process-focused praise and criticism teach children different beliefs about what is ‘good or bad’ and leads to different responses to set-backs.

An observational study of spontaneous parent praise given to children aged one to three years at home, concluded that the causal mechanisms identified in previous experimental work may also be operating in the home environment (Gunderson et al., 2013). Participants were 53 children and their primary caregivers. The children were visited in their homes every four months beginning at 14 months of age. Children’s and parents’ spontaneous interactions were video-taped for a period of 90 minutes while they went about their normal daily activities. The parents and research assistants involved, thought they were participating in a child language development study. Both were unaware that the parents’ praise would be coded later from the videos. The researchers distinguished process praise which emphasised
a child’s effort from person praise which implied that a child possessed a fixed, positive quality. Between the ages of seven to eight these same children completed two orally presented questionnaires about three months apart and in the context of a group of cognitive tasks in a two hour session. Parents’ praise of children’s effort between the ages of 14 to 38 months predicted incremental frameworks or a growth mindset at seven to eight years. However, they did not find the predicted relationship between parents’ use of person praise and children’s later orientation toward an entity framework or fixed mindset. While parents praised boys and girls equally often, parents of boys devoted more praise to their child’s effort, strategies, or actions (process praise) than parents of girls. Girls received more person praise and other types of general praise. Gunderson’s study was continued with these same children in fourth grade (Gunderson, Sorhagen, Gripshover, Dweck, Goldin-Meadow & Levine, 2017). Their findings suggest that process praise leads children to form a growth mindset which in turn improves their academic achievement (in mathematics and reading comprehension) over time.

To evaluate whether parents’ daily praise of children’s success in school contributes to children’s theory of intelligence and the accompanying preference for challenge over time, Pomerantz and Kempner (2013) used a ten-day daily telephone interview to capture mothers’ praise of children’s success in school in their on-going interactions with children. Participants were 120 children, with a mean age of 10, in Chicago public schools (U.S.A.) and their mothers. It was a two-wave study lasting six months. The children’s entity theory of intelligence and preference for challenge were assessed with surveys at both waves. The more mothers’ endorsed performance versus mastery goals, the more they used person praise and the less they used process praise relative to the other responses. Henderlong and Lepper (2002) remind us that parents’ process praise may not always confer benefits on children over time as unless children have actually worked hard then praise for effort may be viewed as untruthful and the ‘double-edged sword’. Covington and Omelich (1979) note that when effort does not lead to success then children may see themselves lacking in ability and may not take on any challenges.

Mueller and Dweck (1998) point out that, as with criticism, it is better to separate ‘the deed from the doer’ so when applying praise to children’s strategies and work habits it is more beneficial than praising a particular trait. When students are praised for the process they
engage in; their effort, strategy, concentration, or persistence then this promotes a growth mind-set with its emphasis on learning and its resilience. On the other hand praising students for their intelligence hands them not motivation and resilience but a fixed mindset with all its vulnerability. This approach may give them a short burst of pride, followed by a string of possible negative consequences. Parents therefore can encourage a growth mindset over a fixed mindset in the type of praise they use with their child and also by their emphasis on the role of effort, resilience and positive strategies in learning. This strategy has implications for teacher use of praise with students and the possible mindset they may be developing, particularly in very young students.

Dweck (2007) had developed her growth mindset theory as a counter to the self-esteem movement of blanketing everyone with praise whether they deserved it or not. Praise was used by parents to make their child feel good about themselves or to protect them from failure. Parents and teachers were sometimes missing the point that it was critical to help the child learn to cope with setbacks and to help them focus on ways to improve. Growth mindset research is now being used inappropriately in the same manner asserts the Alliance of Girls’ Schools Australasia, (2017) as praise is being lavished on effort rather than the quality of the outcome. The focus should be on how effort creates demonstrable progress or success in learning and praise should be tied to learning progress or an actual academic outcome. Students need support in finding a new strategy when something is not working in mathematics. Redoubling efforts without effective strategies becomes a pointless exercise which may lead to fixed mindset beliefs.

Parents and gender.

Parents’ gendered beliefs are relevant to this study as there is a growing body of evidence that parents’ beliefs and values about gender influence their children’s beliefs and values with its consequent effect on mindset (Gladstone, Häfner, Turci, Kneißler & Muenks, 2018). In addition, parental perception of children may be affected by the child’s gender. Räty, Vänskä, Kasanen and Kärkkäinen (2002) in a Finnish study of parents’ explanations of their child’s performance in mathematics and reading found that parents of boys assessed their child’s mathematical ability to be higher than did the parents of girls and explained their son’s mathematical achievement in terms of talent and their daughter’s in terms of effort. No effect was detected in the study of the child’s gender on the parental explanations of failures. Girls
were perceived to surpass boys in reading however these positive results were explained more by effort than those of the boys. Even at the highest reading level the boys’ verbal talent was rated to be a more significant cause of reading success than was the girls. Räty et al. (2002) explain these gender bound beliefs and their relative importance to girls’ academic careers.

The highly competent girls were not entitled to ability-based attributions to the same extent as the highly competent boys – a difference that has been frequently recognised in men’s and women’s causal attributions of their own academic performance ... Our results confirm the importance of parental expectations of a child’s academic accomplishments, which, construed in terms of the gender bound representations of intelligence, are consequential to the child’s academic choices and prospects. (p. 126)

A longitudinal study of 800 children and their parents was reported by Bofah and Hannula (2015). Parents’ values and attitudes were analysed to determine the effect on children’s mathematics performance and later interest, and how these parental attitudes vary with the child’s gender. It was found that parental attitudes were important determinants of children’s mathematics performance and later interests such that girls’ interest in mathematics decreases as their fathers’ gender stereotypes increase. It was also noted in the study that parents provided a more mathematically supportive environment for boys than girls, including the purchase of toys and time spent on activities. Attard et al., (2016) emphasised that parental expectations influence their children’s mathematics achievements and that parents’ perceptions of sons and daughters differed. Lloyd, Gore, Holmes, Smith and Fray (2018) also found that parents were more likely to have university aspirations for their male children aspiring to study STEM subjects compared to the parents of female children who also aspired to study STEM subjects. Lloyd et al. suggest that it is both “possible and conceivable that parents cannot visualize the paths for girls into STEM as clearly as they can for boys” (p. 323).

Herbert and Stipek (2005) suggest that parents may perceive daughters to be better in literacy-related competencies, but may underestimate girls’ performance or overestimate boys’ performance in mathematics especially if they hold stereotypic gender-role beliefs. In
their longitudinal study of 300 elementary grade children, Herbert and Stipek examined academic competency beliefs and assessed the emergence of gender differences in parents’ and teachers’ perceptions of children’s competencies also over time. The study focused on economically disadvantaged children who were at risk of school failure as a consequence of living in poverty. The results indicated that, on average, girls rated their mathematics abilities lower than did boys but there was no corresponding gender difference in actual mathematics achievement. The girls’ underestimation of their mathematics ability took several years in elementary school to develop with a corresponding underestimation of their literacy ability. The researchers query whether these girls from low income families were modest or less self-confident than their actual achievement suggests. The adult perceptions of children’s abilities showed that teachers, not parents, rated girls’ literacy abilities higher than boys; and parents, but not teachers, rated boys’ mathematics abilities higher than girls. Teacher ratings mirrored gender differences found in actual performance more than did parents. By fifth grade, parents’ judgments of their children’s competencies were a strong predictor of children’s own judgments of their mathematics ability. Perhaps parents subtly conveyed gender stereotypic beliefs which their children internalised. Gladstone et al., (2018) note that “children’s beliefs and values in mathematics are directly and positively related to their parents’ perceptions of children’s mathematics abilities and how valuable mathematics is for their child” (p. 221).

**Conclusions from research on factors which influence mindset.**

The literature to date indicates that mindsets “do not develop in a psychological vacuum”, but are the result of many closely interrelated factors such as broad cultural beliefs, parent/family influences and school related factors (Wang & Degol, 2013, p. 310). The preceding section has examined the ‘big picture’ on prevailing cultural beliefs of eastern and western societies including western ambivalence to the role of effort; the importance of the school as a developmental context for children; parent and teacher praise and feedback followed by studies using experimental type methodology whose findings align with parent and teacher studies of factors influencing the development of mindset. The role of parents and child gender was also reviewed in light of these factors. The review of literature in this section demonstrates a need for more detailed studies related to ways in which mindset develops, particularly in Australian schools.
Mathematics, Mindset and Gender

The relationship between mathematics and gender has been the subject of a wealth of research, however there has been little research to date linking mindset with mathematics and gender. Mathematics is a subject area that communicates the strongest, fixed ability messages and thinking (Boaler, 2013) and this then raises questions about ways in which mindset relates to specific disciplines of study within schools and students’ participation and engagement in mathematics. Moreover, this raises questions about gender, mindset and mathematics.

A study of over 14,000 secondary students in Hong Kong (Mok et al., 2011), found significant gender differences in ascriptions to ability, effort and strategy use in school performance. Females placed more emphasis than males on ability and strategy as causes of their academic failure and on effort and strategy as causes of their academic successes. The authors reason that these findings may reflect stereotyping of academic achievement as a male pursuit and a male tendency to have an ‘illusionary glow’ regarding their academic ability. Stricker, Rock and Burton (1993) in their study of gender for confidence in English, mathematics, science and history, found that “women lacking confidence in their academic ability may compensate by working harder, while men in that situation may simply give up” (p. 717). These gender differences in attribution of failure and success have been consistently found in Western research (Brandell & Staberg, 2008; Burkley, Parker, Stermer & Burkley, 2010; Nosek et al., 2002; Watt, 2006). However, in Mok et al.’s study both genders across all year levels nominated effort as the most important reason for academic achievement.

According to Belcher, Frey and Yankeelov (2006), gender significantly influences students’ mathematics self-concept, mathematics self-confidence and the perceived usefulness of mathematics. Females are more likely to opt out of the more difficult levels of mathematics rather than males (Watt, 2006). Forgasz (1998) reports that more females than males complete Year 12 and a higher proportion of females than males are enrolled in university courses. Females however, are less likely than males to study the highest level of mathematics for the Higher School Certificate (H.S.C.) and fewer enroll in STEM subjects at university. This decline is a matter for significant concern, for reasons related to national economic growth and social equity. The psychological research provides reasons, such as females having less
confidence, more anxiety, lower levels of self-esteem and self-efficacy and feelings of not belonging, for declining participation in post-compulsory mathematics particularly at the advanced level. The sociological research offers explanations for this declining trend in terms of the perceived difficulty of the subject, the stereotype of mathematics as a male subject and the general belief of a natural talent for mathematics that is innate. This section of the literature review will examine some of the broad literature related to gender and mathematics and explore some ways in which that literature relates to implicit beliefs about intelligence.

**Gender differences in attitudes towards mathematics - psychological research.**

Psychological research offers one level of explanation for the gender related attitudes toward and participation in mathematics. This is supported by the work of Ercikan, McCreith and Lapointe (2005), who argued that the strongest predictor of participation of students from Canada, Norway and the U.S.A. in advanced mathematics courses were students’ attitudes towards mathematics. Watt (2006) in her Australian study on the role of motivation found that boys both planned and undertook higher levels of mathematics than girls in senior high school and boys also planned more highly mathematics related careers than girls. Again Watt explained these differences as being related to adolescents’ motivations over and above their prior mathematical achievements. Tully and Jacobs (2010) found women were more likely to choose engineering at tertiary level if they believed they were good at mathematics, whereas men were more impacted by male role models of family members who were practising engineers. Leaper et al. (2012) point out that students’ achievement is generally lower in subjects in which they do not see themselves as competent, that is, they have low ability beliefs and find the subject uninteresting or of low value.

Many research studies, report that girls have less confidence in their mathematical abilities and more anxiety than boys (Brown et al., 2008; Close & Shiel, 2009; Forgasz & Leder, 1996; Maloney et al., 2013; Nagy, Watt, Eccles, Trautwein, Lüdtke & Baumert, 2010; Thomson, 2010); girls experience more frustration and anxiety when solving problems than boys (Arroyo, Muldner, Schultz, Burleson, Wixon & Woolf, 2016); anxiety may be linked to narrow conceptions of what constitutes mathematics (Foushee, Jansen & Srinivasan, 2017); girls can show lower levels of self-esteem and self-efficacy than boys (Diseth et al., 2013; Usher & Pajares, 2009); girls may feel that they don’t belong in mathematics or exist on the margins
of the practice (Good et al., 2012; Rodd & Bartholomew, 2006; Solomon et al., 2011); girls may rate themselves as having lower ability than boys’ ability rating (Watt, Eccles & Durik, 2006; Yeung, 2011; Hodgen et al. 2013) and may underestimate their action and problem solving competencies in comparison with boys (Ziegler, Heller & Broome, 1996). The following studies outline some of these psychological factors that affect participation in mathematics.

Mathematics may be regarded as difficult and boring (Jones, Howe & Rua, 2000; Watt, 2004). Grootenboer (2013), notes a common societal perspective that mathematics is portrayed as “dull, irrelevant and useless” (p. 324). Students believe that it takes more effort to successfully complete STEM subjects which they see as a difficult challenge (Watt, 2004). According to Watt (2005), gender differences in mathematics participation are not due to differences in boys’ and girls’ mathematics achievement but are explained by adolescents’ perceptions related to mathematics. She found that the strongest influence on mathematics participation for students was the extent to which they were interested in and liked mathematics. A secondary factor was adolescents’ self-perceptions about their own mathematics talent and their expectations for success in this discipline. Boys indicated that they liked mathematics more than girls did and boys rated their math talent and success expectancies significantly higher than girls. Forgasz and Leder (1996) contend that males hold more functional beliefs about themselves as learners of mathematics than do females and that females are less likely than males to attribute mathematical success to ability and failure to lack of effort, and more likely to attribute failure to lack of ability. According to Degol, Wang, Zhang and Allerton (2017), males were more likely to have higher expectancy beliefs in mathematics than females which is associated with higher grades, however, in their study of 1449 high school students in grades nine to twelve, females had lower expectancy beliefs than males, but did not have lower mathematics grades than males. Boaler, William and Brown (2000) argue that the emphasis on ability grouping practices in high school mathematics may impact upon student experiences “in profound and largely negative ways” (p. 632). In their study, fast paced lessons with pressure to succeed affected the most able girls.

Comforting struggling students in mathematics can demotivate them and discourage their participation in pursuing further studies (Rattan et al., 2012). In a study of university undergraduates in the U.S.A., the researchers found that instructors with an entity theory of intelligence were more likely to comfort students for low mathematics’ ability and express
their support and encouragement in unproductive ways, such as advising the student to drop the course. The comfort feedback led students to feel less motivated and to expect lower grades in the future. They also viewed the instructor as having lower engagement in the students’ learning. The authors point out that well-meaning behaviours on the part of teachers can lead to highly negative outcomes for the recipient. This study highlights how pedagogical practices in learning institutions can lock students into low achievement and future lower participation in mathematics related careers.

A motivational analysis of high school enrolments in Australia and the U.S.A. (Watt et al. 2006), found that boys in Australia selected higher levels of mathematics than girls, although not in the U.S.A. sample. However, in the U.S.A., courses are structured around topic areas, rather than along an underlying continuum of complexity as in the NSW syllabus. This may account for enrolment differences between the two countries. The intrinsic value of mathematics (interest in and liking of mathematics) was the strongest influence on the Australian adolescents’ choices for mathematics participation, with ability beliefs also influencing choices over and above prior mathematical achievement. Ability related beliefs and value differences also predicted adolescents’ choices in the USA sample, more strongly for girls than boys. Thomson (2010) notes a long term finding from the Trends in International Mathematics and Science Study (TIMSS); that boys are more self-confident and have higher levels of self-concept and lower levels of anxiety in mathematics, even when girls outperform them. Thomson poses the intriguing question of why girls still doubt their abilities even when they are achieving at a high level. She argues that if girls do not see mathematics as an area of strength and suffer from mathematics anxiety then despite their achievement levels it is unlikely that they will continue their studies at senior level. Close and Shiel (2009) also found that females showed higher levels of anxiety about mathematics than males. In a German study, Handel, Duan, Sutherland and Ziegler (2014) reported that female students were more anxious at being labelled a “nerd” than their male counterparts in mathematics (p. 891). This suggests that the female students may regard their higher performance in mathematics as leading to a possible loss of image. In a co-educational school, this may lead to females showing less effort in mathematics.

The development of mathematics self-concept was examined by Nagy et al. (2010) across grades 7-12 in Australia, U.S.A. and Germany. There was a general decline in mathematics
self-concept with age in all three countries. Consistent gender differences in mathematics self-concept were found with males scoring higher than females at the beginning of grade 7 in all settings. Hodgen et al. (2013) expressed a concern that female students were more likely to underestimate their mathematical competence than male students and therefore less likely to pursue further studies in mathematics.

The sense of belonging in mathematics, that is, one’s feelings of membership and acceptance in the male domain, according to Good et al. (2012), is an important factor in women’s participation in this discipline. In a longitudinal study of calculus students, they found the message that mathematics ability is a fixed trait and the acceptance of this stereotype that females have less of this ability than males, combines to erode women’s but not men’s sense of belonging in mathematics. This in turn affects women’s desire to pursue mathematics in the future. The authors also point out that it is in the middle years of secondary school that girls’ confidence in and liking of mathematics begins to diminish. Single-sex schooling in Switzerland provided evidence of improvement in the performance of female students in mathematics with increasing positive effect if the class was taught by a male teacher (Eisenkopf, Hessami, Fischbacher & Ursprung, 2011). Parents’ and teachers’ expectations for children’s mathematical competence are often gender-biased and can influence children’s mathematics attitudes and performance (Gunderson et al., 2012). The researchers argue for new research directions on mathematics and gender that focus on how parents’ praise influences children’s implicit theories of intelligence and how implicit attitudes are transmitted from adults to children.

This research study extends previous findings in these new directions.

**Gender differences in attitudes towards mathematics – sociological research.**

Research on gender differences in attitudes towards mathematics provides one level of explanation for the gender differences in participation in mathematics. This research is complemented by research which adopts a broader perspective, in which prevailing social attitudes, beliefs and stereotypes regarding mathematics are explored. This sociological research provides an understanding of why it is that girls have more negative attitudes than boys towards mathematics. The mindset framework offers insight into this question. Mathematics can be seen to be linked to mindset in major ways; the belief that mathematics
is regarded as a difficult subject to do well in; the belief that mathematical achievement is linked to talent and being naturally good at the subject, and the belief that males are better at mathematics than females. These beliefs can all contribute to a fixed mindset in mathematics for girls and boys.

**Mathematics - a difficult subject.**

Many studies have shown that mathematics is seen as a “difficult” subject, which may not be within the reach of everyone (Bonne, 2016; Mendick 2005a). Mathematics is seen as inherently difficult and indeed mathematics seems to be the last bastion where this belief is still tenaciously held (Mendick, Epstein & Moreau, 2008). The view of mathematics as a difficult, elitist subject was expressed by Nardi and Steward (2003) in the following manner:

> Mathematics exposes the weaknesses of the intelligence of any individual who engages with it and therefore puts confidence in their intellectual capacity at risk. (p. 362)

The Expectancy-Value Model of Achievement Motivation (Wigfield & Eccles, 2000), focuses on subjective values that individuals assign to school subjects or tasks and on ability beliefs. The perceived cost of a subject in terms of effort and evoked emotions, such as fear of failure, is one of the four values in this model. Van Tuijl and van der Molen (2015) report that Wigfield and Eccles’ dimension of costs or efforts is especially relevant to a subject such as mathematics since many students consider this subject to be difficult.

Stodolsky, Salk and Glaessner (1991) interviewed 60 fifth grade pupils from six schools in the U.S.A. The researchers found that students’ conceptions and attitudes regarding mathematics and social studies were different. Social studies experiences were characterised by whether the topics were interesting or boring whereas the students’ characterised positive and negative experiences in mathematics in regard to their success or ability to do the work. Interestingly, more students thought they could learn social studies on their own but not mathematics. Their findings suggest that difficulty is a salient dimension for mathematics. Brown et al. (2008) analysed questionnaire responses from 1500 students in 17 schools. The authors found that perceived difficulty and lack of confidence were the most important reasons for students not continuing with mathematics. In semi-structured interviews with
adolescents, Murray (2011) reported that the most commonly offered reason for declining participation in mathematics (60% of respondents) was that mathematics was ‘difficult’, which then had implications for students’ self-belief and identity regarding mathematics. Unfortunately in our westernised society, a pervasive myth still persists that to be successful in mathematics requires brilliance (Chestnut, Lei, Leslie & Cimpian, 2018). Being brilliant at mathematics is often linked with natural talent and masculinity.

Blackwell et al. (2007) argued that mathematics was a sufficiently challenging subject to trigger the motivational patterns related to mindset, which may not manifest in situations of low challenge. As mathematics is a subject that many students find difficult, it can trigger distinct motivational patterns related to mindset, such as questioning one’s ability: am I smart enough to do mathematics? Students may select subjects in which they feel comfortable and are not exposed to challenges or difficulties (Dweck, 2008).

**Natural or innate ability.**

According to Else-Quest, Hyde and Linn (2010), despite academic performance similarities to their male peers, females are more likely to doubt their abilities in mathematics and science. Cultural beliefs about the role of effort and ability in academic achievement can exert a powerful influence on students’ attitudes and performance. Powerful cultural discourses define the subject of mathematics in particular. Researchers have explored the idea that mathematical ability is seen as *innate*. In studies that specifically examine beliefs about mathematics and science, it has been noted that students tend to have more of a fixed view of mathematics skills than of other intellectual skills (Dweck, 2008). Females and especially bright girls tend towards fixed beliefs regarding their intelligence and especially their mathematical ability. (Dweck, 2006; Nix, Perez-Felkner & Thomas, 2015). Todor’s (2014) results also showed that girls tend to hold a fixed mindset and, compared with the boys, they felt less efficacious and competent in mathematics. Van Aalderen-Smeets and Walma van der Molen (2016) point out that in STEM based subjects, the relation between holding a fixed mindset and gender stereotypical beliefs is stronger for females compared to males. If girls believe that their aptitude for mathematics is innate and they have less of it because they are female then this will affect their achievement in mathematics.
Sinicrope, Eppler, Preston and Ironsmith (2015) report from the Conference Board of the Mathematical Sciences (2012) that a long held belief among Americans is that either you “can do mathematics or you cannot” (p. 57). Chestnut et al. (2018) point out that “doing mathematics requires some sort of innate quality - a spark of brilliance or a gift whose presence determines whether someone is a math person or not” (p. 1). According to Meyer, Cimpian and Leslie (2015), women are underrepresented in fields that emphasise the need for raw ability rather than effort as women are influenced by the cultural stereotyping of gender and ability such that men are more likely than women to possess raw ability. Meyer et al. (2015) call their hypothesis the field ability beliefs (FAB) hypothesis. This hypothesis predicts that:

Women will be underrepresented in fields believed to emphasise brilliance and inherent ability as the key to success; this is because women are often stereotyped as lacking the same sort of innate intelligence as men, and thus women will be discouraged from participating in fields to the extent that these fields are perceived as requiring this type of intelligence. (Meyer et al., 2015, p. 9)

Chestnut et al. (2018) note that this language of brilliance undermines females’ interest in mathematics by increasing their anxiety and decreasing their sense of belonging. Similarly, Wang and Degol (2016), suggest that:

Women may be avoiding challenging careers in STEM not only because they erroneously believe that innate intelligence is needed for success in these fields but also because they erroneously believe that they belong to a group that is less likely to possess the qualities needed for success in these fields. (p. 311)

Usher and Pajares (2009) study on self-efficacy in mathematics found also that female success in mathematics was more likely to be attributed to hard work than to innate ability. Eighth graders, parents and teachers cited conscientiousness in mathematics as playing an integral role in female mathematics performance and attributed male performance to innate ability. These beliefs can communicate to girls that they do not have the ability to perform mathematics and must make up for that with hard work. Degol et al. (2017) report that research has consistently shown that females have lower expectations of success in mathematics due to lower ability self-concepts despite equivalent mathematics performance.
compared to males. These self-defeating thoughts and beliefs may continue to operate as a barrier to further participation in mathematics at the non-compulsory level.

A study of students in England revealed a common view that there is a predetermined level of mathematical study that students cannot possibly exceed (Hodgen et al., 2013). R. Marks, (2013) points out there is an ‘ideology of ability’ in mathematics education in the United Kingdom, which inhibits students’ learning. She reports that 90% of teachers and parents surveyed in the United Kingdom believe genetic influences to be more than, or at least as important as, environmental factors in the development of ability. She laments the lack of questioning of mathematics’ educational practices that have at their basis a ‘can/can’t do’ dichotomy. R. Marks like Boaler (1997b, 2013) and Dweck (2008) contends that grading or streaming encourages the belief that some individuals are born to do mathematics and others not. Importantly when students are ‘pigeon holed’ into different streams with very little chance of changing classes then their expectations of success in mathematics and that of their teachers may be affected. R. Marks (2011) also raises the question of how many elements of the school day, aside from mathematics teaching, are implicated in reproducing ability discourses.

Marshman, Kalender, Schunn, Nokes-Malach and Singh (2017) found that females’ physics intelligence mindset became more fixed as compared to males’ physics intelligence mindset after taking an algebra-based physics 2 course. This result suggests that the women related being ‘brilliant’ to ‘doing physics’. Grit or resilience was the only construct on which females reported average scores higher than males in this study. The research on natural talent or abilities highlights what Degol, Wang, Zhang and Allerton (2017) describe as “significant gender differences in how males and females cognitively appraise their math abilities” (p. 976).

Parents’ stereotypical beliefs of innate masculine superiority in mathematics may be linked to their daughters’ lower perceptions of their own mathematical ability. Degol et al. (2017) suggest that:

Adults who communicate to females that effort in mathematics is an indicator of lower ability, instead of a drive or passion for hard work and success, may
inadvertently be derailing or undermining their perceived competence and ability. (p. 11)

Chestnut et al. (2018) advocate the emphasis of growth in learning over brilliance and note the tendency of some parents and teachers to frame boys as the standard for girls in mathematics achievement. For example, the expression “girls are as good as boys at mathematics” is often heard but rarely would one hear, “boys are as good as girls at mathematics”. The authors emphasise that consistently framing boys as the standard for girls – even when the statement is intended to be egalitarian – thus actually teach children that boys have more raw talent. (Chestnut et al., 2018, p. 4)

**Imposter syndrome.**

The imposter syndrome may also be linked to a person’s implicit beliefs of intelligence. This term was first used by Clance and Imes (1978) to describe highly successful women who had difficulty recognising their own achievements and continued to feel as though they were imposters in their careers. Later research has also demonstrated that men can also exhibit characteristics of this syndrome or phenomenon (Ivie, White & Chu, 2016). A definition of the imposter syndrome provided by Ivie et al. (2016) emphasised that:

> The syndrome is defined by believing that one’s accomplishments came about not through genuine ability, but as a result of having been lucky, having worked harder than others, and having manipulated other people’s impressions. (p. 3)

According to Ivie et al. (2016), people with the imposter syndrome can discount their successes by attributing them to hard work, while believing that others sail through based on natural talent. There is a sense of devaluing one’s own ability and a ‘fear’ that people will soon realise that they are not really capable after all. This syndrome may also be linked to having a fixed mindset as having to work hard may be regarded as making up for insufficient ability that is stable and unalterable.

**A ‘masculine’ subject.**

Closely related to the research showing that mathematical ability is seen as innate, is research that explores the notion that mathematics is regarded as a ‘male’ domain (Leder, Forgasz & Jackson, 2014). Powers of rationality and mathematical thinking are bound up with the
cultural definition of masculinity (Brandell & Staberg, 2008). Success in mathematics has traditionally been associated with males and doing mathematics can be seen as doing masculinity (Mendick, 2005a). Males more than females view mathematics as a male domain (Forgasz & Leder, 1996). Mathematics has been viewed as “the preserve of males - typically white and middle class” (Leder & Forgasz, 2008, p. 2). Historically, women have been invisible in mathematics. Mathematicians are often portrayed as mad or at least eccentric and different, ‘geeky’, ‘nerdy’, mostly male and almost invariably white (Epstein, Mendick & Moreau, 2010). Given the status of mathematics as a proof of self (Mendick, 2005b), success in the subject is central to a student’s intellectual identity. Bian, Leslie and Cimpian (2017) emphasise that the earlier children acquire the idea that brilliance is a male quality, the stronger its influence may be on their career aspirations, particularly in fields where brilliance is cherished such as in mathematics, physics and philosophy. They point out that “if children absorb and act on these ideas then many capable girls are likely to have already veered away from certain fields by the time they reach college” (p. 1).

A study in Victoria, Australia (Leder & Forgasz, 2010) on the general public’s views of gender issues and school mathematics, found that in general, boys were considered to be better at mathematics than girls. The researchers point out that there are still remnants of the male mathematics stereotype in Australian society. Good, Aronson and Harder (2008) reported that even women enrolled in a rigorous and fast-paced final calculus course at university can be vulnerable to the effects of negative stereotypes.

In a study examining students’ perceptions about gender and mathematics in the U.S.A., Kloosterman, Tassell, Ponniah and Essex (2008) reported that students believed that mathematics was gender neutral however secondary school females, more strongly than males, believed that mathematics was not a male domain. Their study also revealed that pre-service elementary teachers were less convinced than secondary school females that mathematics was gender-neutral and not a male or female domain. Both male and female secondary students, according to Kloosterman et al. (2008), noticed differences in the way boys and girls were treated in mathematics classes, for example, boys were causing more distractions while girls were caring more about doing well. Secondary school males who believed they were average or below average at mathematics had less gender-neutral perceptions than males who believed they were good mathematics students. The researchers
concluded that perceptions of mathematics and gender in the U.S.A. were still an issue in secondary and college classroom settings.

Mendick (2005b) notes other culturally powerful ideas that portray mathematics as a male domain, include images of mathematicians as male, reclusive individuals working in isolation, perhaps socially inept, for example, in Hollywood films such as *A Beautiful Mind* (Grazer & Howard, 2001) and *Good Will Hunting* (Bender, 1998) and the notion that women and mathematics do not go together as women are not rational/logical beings. Images of mathematics and mathematicians within the media carry the message that mathematics is not for everyone by reinforcing notions of ‘natural ability’. The film *Hidden Figures* (Melfi, 2016), portraying the work of three black females (double stereotype of race and gender) working at NASA as ‘human computers’ in the sixties was a celebration of women whose achievements have largely gone unnoticed in our western culture. If these women are viewed as being atypical by film audiences then the success of this movie will not necessarily inspire females into STEM fields. Steele, Levin, Blecksmith and Shahverdian (2008) remark that “the public remains incapable of considering women’s success in mathematics as ordinary or normal” (p. 31). All of these beliefs have a profound effect on women’s mathematical attitudes, performance and participation (Mendick, 2005b).

Stereotypical comparisons concerning the nature of male and female success in mathematics can be based on male ‘natural flair’ contrasted with female ‘effort’ according to Solomon et al. (2011). Boys are more likely than girls to be considered as effortless achievers. To be a boy is to succeed without trying and academic hard work is generally incompatible with ‘cool’ masculinities in schools (Jackson & Dempster, 2009; Jackson & Nyström, 2014). By analyzing Hansard transcriptions of hearings from the Australian Parliamentary Inquiry into the Education of Boys, Hodgetts (2008), highlighted the dominance in Australia of the discourse that conflates masculine learning approaches with authentic academic achievement and showed that participants in the inquiry drew upon gender binaries in representing students that “worked to associate masculinity with authentic learning, such that the success of male students was naturalised even in the absence of achievement and conversely, the association of femininity and inauthentic learning worked to undermine female students’ demonstrated success” (p. 475). There is still a myth perpetuated in some discourses in our western society that boys and men are ‘naturally’ brilliant relative to girls and women (Fisher, 2014; Francis,
Interviews with male students in England and Sweden (Jackson & Nyström, 2014), found a common representation by males to be the “epitome of cool, authentic, masculine, effortless achievement” (p. 9). The authors noted that it was particularly valuable for young men to be regarded as effortless achievers in ‘difficult, masculine’ subjects such as mathematics as the subject was generally regarded as a more powerful proof of ‘natural ability’ than other subjects. Jackson and Nyström (2014) noted that “girls tend to be positioned as diligent plodders who are careful, neat and lacking flair, while boys are positioned as sloppy yet having the necessary spark to pull it off” (p. 8).

The perceived amount of effort it takes to succeed may be an important cue influencing female belonging and motivation to pursue and persist in mathematics and science related studies (Smith, Lewis, Hawthorne & Hodges, 2013). If females are not viewed as ‘naturally’ talented in mathematics then it follows they will need to work harder to be good at mathematics (Boaler, 2002). In the domain of mathematics, effort can be equated with less ability. Boys’ lack of effort can be seen as signifying greater intelligence than girls better but more effortful performances (Walkerdine, 1998). The notion of effortless achievement is inextricably linked to conceptions of intelligence as natural and fixed (Jackson & Nyström, 2014), who argue that white, elite or middle-class males are more likely to position themselves as effortless achievers than students in other social categories and contexts. Howe and Berenson’s (2003) study also highlighted the belief in hard work by high achieving girls in advanced mathematics classes.

Viewing mathematical ability as a gift or an innate talent that males possess in more abundance can not only make females vulnerable to declining performance, but susceptible also to setbacks and stereotypes (Dweck, 2008). My study raises key questions about how females understand ability and perceive the need for effort in mathematics.

**Research that connects mindset, mathematics and gender.**

Research evidence supports the proposition that students’ mindsets play a key role in their mathematics engagement, participation and achievement (Boaler, 2013; Burkley et al., 2010; Dweck, 2008). Burkley et al. (2010) showed that women who believed their mathematics skills were fixed and unchangeable showed less interest in mathematics tasks and less mathematics identification after failure in a mathematics test than women with a growth mindset. The
researchers emphasised that a fixed mindset can make women vulnerable to mathematics disengagement.

Nix et al. (2015) note that students’ self-assessments of their mathematics ability appear to vary by gender and influence STEM degree choice. They found that females who enrolled in more advanced mathematics seemed to have more negative self-assessments of their ability and mindsets regarding mathematics ability than males. Adjustments to women’s mindsets Nix et al. (2015) suggest could help with gaps in STEM participation. The researchers argued that if girls are more inclined to view their abilities as fixed rather than malleable, then they may also believe that they are not capable when they encounter setbacks on challenging mathematics tasks. If gender moderates perceived ability then this will become very important, given the prevailing stereotypes that girls encounter regarding their mathematics ability. Dweck (2007) emphasised that girls would benefit from growth mindset training and Degol et al. (2017) in identifying pathways between gender, mindset and motivation reported that females had higher mathematics achievement than males when they endorsed a growth mindset. They note that “while a growth mindset in mathematics appears to be beneficial for both genders, it is especially beneficial for adolescent females” (p. 10).

Further research has considered student mindset and its relationship to stereotype threat. Much research has shown that a growth mindset can reduce or negate stereotype threat. Studies have demonstrated that having a growth mind-set is important for students who may have a negative stereotype about their abilities such as African-American students or girls in mathematics or science classes (Aronson et al., 2002; Good, Aronson & Harder, 2008). If females believe that ability can be developed or cultivated through their efforts then the stereotype is less credible. Good et al. (2003) showed that female seventh grade students mentored by college students could overcome the anxiety-inducing effects of stereotype threat and improve their standardised test scores. The students were encouraged to view intelligence as malleable or to attribute difficulties in the seventh grade to the novelty of the educational setting.

The sense of belonging in mathematics, that is, one’s feelings of membership and acceptance in this domain is an important factor in women’s participation (Good et al., 2012). Eschenbach, Virnoche, Cashman and Lord (2014) report that women experiencing stereotype threat in mathematics may feel that they do not belong in mathematics’ classes and
misidentify with mathematics as an important domain, that is, avoid or drop the subject as an identity or basis of self-esteem. Aronson et al. (2002) showed that a growth mindset protects females’ belief that they belong to the mathematics community. Good et al. (2012) conducted a longitudinal study of college calculus students, and the effect of perceived stereotypes and messages conveyed within these courses. Females who reported that their college mathematics environment contained messages that mathematics ability is a fixed trait and that females have less mathematical ability than males showed an eroding sense of belonging in mathematics. This was accompanied by a decreased intention to take mathematics in the future and a decrease in their final grades in the course. These messages did not affect male students’ sense of belonging in mathematics.

The reviewed research highlights the important role of mindset and gender differences in students’ mathematics participation and possible career explorations.

**Conclusion**

In this review, I have presented an overview of implicit theories of intelligence or mindset. Dweck (2000) argued that issues of fixedness and malleability of beliefs about intelligence are fundamental to human cognition and critical to our understanding of the world. A large body of research has demonstrated that student mindset affects the way that students view the role of effort in their schoolwork and consequently their response to challenges, mistakes and failure. Overall, a growth mindset has been linked to higher academic achievement and well-being outcomes. Intervention studies have shown that a growth mindset can be developed with positive benefits, at least in the short term.

The review has explored the factors which influence mindset, including cultural beliefs, particularly noting differences in Eastern and Western cultural beliefs about the malleability of intelligence and the importance of effort. There are a range of school-related factors that can influence mindset. These include peer culture, gender stereotypes, subject streaming/fixed sets, and the transition from primary to secondary school. The use of praise and feedback by parents and teachers can play a key role in the development of mindset.

The review has examined declining student participation in post-compulsory mathematics and the marked gender difference in these trends. These trends are significant for reasons of
social equity and economic wellbeing. Declining participation in mathematics has been considered in the light of research related to mindset, mathematics and gender. While there is relatively little research that directly links mindset and mathematics, mindset offers a useful way of understanding motivation and participation in mathematics. Mathematics is regarded as a difficult subject; there is a perception that mathematics ability is a fixed trait and that females have less of this ability than males. These beliefs may work together to erode girls’ sense that they belong in mathematics and hence their desire to pursue mathematics in the future at a senior level or in their careers.

There has been limited exploration of Dweck’s implicit theories of intelligence in Australian education. Most of the research to date has been quantitative, providing insight into statistical trends concerning mindset. As my study used mixed methods, it extends and deepens the understanding of mindset in a naturalistic school setting, by providing richer and more nuanced understandings of mindset. Mindset provides a powerful lens through which to view the problem of declining student participation in post-compulsory secondary mathematics. A detailed exploration of students’ beliefs about the role of ability and effort in mathematics provides further understanding of this important issue.
Chapter Three: Methodology

Introduction

This Chapter is an overview of the approaches selected to investigate the implicit theories of intelligence in general, and about mathematics in particular, held by female secondary students and their perceptions of the factors which influence these implicit beliefs.

Chapter Three has multiple purposes including:

- outlining and justifying the methodological approach chosen;
- explaining and justifying the data collection and analysis of techniques used for each data source;
- identifying and discussing considerations of validity and reliability; and
- presenting ethical considerations associated with the conduct of the study.

Research Questions

As stated in Chapter One, the task of investigating students’ mindsets, particularly those relating to mathematics was framed by the following research questions:

1. What implicit theories of intelligence or mindset do female secondary students hold? In particular, what beliefs do they hold about ability and effort and their roles in academic achievement?

2. What is the relationship between these beliefs and students’ self-reported learning behaviours?

3. What implicit theories of intelligence specifically related to mathematics do female secondary students hold?

4. What is the relationship between these beliefs and their participation in mathematics?

5. What are students’ perceptions of the factors influencing their beliefs about intelligence in general and ability in mathematics in particular?
As outlined in Chapter One, my study stemmed from my experiences as Principal and science/mathematics teacher, in an all-girls secondary school. In order to investigate the complexity of factors that influenced girls’ mindset beliefs, particularly about mathematics, I have adopted a mixed methods approach to the study. This methodological decision was adopted for several reasons. Firstly, to date, quantitative methodologies such as the use of fixed choice questionnaires, have dominated data collection in the mindset literature. Additionally, combining the use of survey method with semi-structured interviews with Years 7-12 students in the sample school, allowed for triangulation of data sets (Johnson, Onwuegbuzie & Turner, 2007). Lastly, “layering” survey data with the elaborations of students’ voices from interviews, created the opportunity to contextualise information and delve into the complexities of students’ behaviours and beliefs (Punch, 2005). Thus this layering allowed spaces for examining the students’ perspectives of effort and ability: concepts rarely reported in the research literature by the use of student voice.

**Mixed methods.**

Mixed methods research is a term employed to describe research that combines the use of both quantitative research and qualitative research (Bryman, 2012). Teddie and Taskakkori (2009) define mixed methods research questions as those “concerned with the unknown aspects of a phenomena and are answered with information that is presented in both narrative and numerical forms” (p. 129). In relation to a mixed methods approach, Gay, Mills and Airasian (2012) emphasise that mixed method research “builds on the synergy and strength that exists between quantitative and qualitative research methods in order to understand a phenomenon more fully than is possible using either quantitative or qualitative methods alone” (p. 481). Furthermore, according to Denscombe (2008), the mixed methods approach has emerged as a ‘third paradigm’ for social research which is sufficiently flexible and multilayered to reflect the reality of social research in the 21st century (p. 271).

There are varied perspectives on the nature of mixed methods research and the reasons for using mixed methods. Johnson and Onwuegbuzie (2004) argue that pragmatism is the primary philosophy underpinning mixed methods research. According to these authors the central maxim of mixed methods research is: “choose the combination or mixture of methods and procedures that works best for answering your research questions” (p. 17). Moreover, they
make the case that the broad goal of mixed methods research pertains to practical action, that is the use of empirical findings to understand social phenomena and to inform action. Onwuegbuzie, Johnson and Collins (2009) suggest:

The pragmatist paradigm offers an epistemological justification and logic for mixing approaches and methods. This type of research should be used when the nexus of contingencies in a situation, in relation to one’s research questions suggests that mixed methods research is likely to provide superior research findings and outcomes. (p. 128)

As an example of research related to my study, Donohoe et al. (2012) used a mixed methods approach to investigate the impact of an online intervention (Brainology) on the mindset and resiliency of secondary school students. The researchers argued that this approach was useful such that one type of data was not satisfactory and explained their reasoning in the following manner:

As the mindset and resiliency of young people are complex, one type of data was not believed to be adequate. Qualitative measures served to give a more comprehensive picture of the topic and provide insight into the quantitative finding. It was also important to give the participants a voice. (Donohoe et al., 2012, p. 646)

Therefore, this study was designed to include two relatively independent but complementary phases. Creswell (2009) calls this an embedded design. As noted by Mertens (2015), the “inferences made on the basis of the results of each strand are pulled together to form meta-inferences at the end of the study” (p. 308).

**Site and participant recruitment**

The site selected for this study was a Catholic secondary college in the Central West of NSW, in which I held the position as Principal. I selected this site for exploration based on my observations of students’ selection of mathematics during their senior years of schooling, its convenience, the fact that the site was an all-girls school, and my direct relationship with the potential participant sample. Given my role as the Principal at the time of the study, I had open access to the site, and to the students, which allowed me the opportunity to build a full and ‘insider’ view of the research context. This is known as convenience sampling.
Convenience sampling (also known as availability sampling) is a specific type of non-probability sampling method that relies on data collection from population members who “can conveniently be recruited to participate in the study” (Hibberts, Johnson & Hudson, 2013, p. 66). All students were invited to participate: there was no exclusion criteria.

The college had a student population of 592 at the time of the study. All students at the school were invited to participate in the study. The ages of the students ranged from 12-18 years. The research was explained at form meetings by the Year Coordinator and a questionnaire was distributed in class by the students’ respective Religious Education teacher. In the following week, after completion of the questionnaire, all students at the school were invited by their Year Coordinators during their form assemblies to participate in an individual interview with me about mindset and mathematics. In order to minimise claims of coercion or bias I removed myself from the recruitment procedures (Appendix A).

**Data Collection Methods**

Two tools were employed to gather data from the participant samples: a questionnaire and semi-structured interviews.

**Questionnaire justification**

Dweck’s *Implicit Theories of Intelligence Scale* questionnaire was employed to investigate students’ implicit beliefs about intelligence in general, and in mathematics. As the seminal researcher in self-theories and motivation, Dweck’s (2000) implicit belief statements formed the basis of the questionnaire for this study.

In general, questionnaires act as inexpensive and time-efficient means of data gathering from a large sample (Punch, 2005), and can vary in complexity from descriptive to explanatory (Burns, 2000). A questionnaire provides the opportunity to include a range of closed and structured which assist the researcher to observe patterns and draw comparisons during analysis. Data collation and analysis are able to be performed expeditiously with the data examined for statistical trends using statistical software such as IBM SPSS. Further strengths of a questionnaire as a data gathering tool, include the ability to be validated with existing research, and the absence of interviewer effects, resulting in interview variability. For the respondent, there is also the advantage of being able to work through the questions at their
own speed (O’Toole & Beckett, 2010). Lastly, questionnaire data can be aggregated, resulting in anonymity for the participant.

However, there are several disadvantages to using a questionnaire. The questionnaire must be relatively brief and easy to complete, otherwise participants may omit questions, if instructions are unclear. In addition, employing a questionnaire has the potential to result in missing data, as the researcher does not have the opportunity to intervene during questionnaire completion. Bryman (2012) identifies the use of questionnaires as limiting as the ability to prompt or probe the participant is not provided, and the opportunity to modify questions that suit a particular participant is not possible.

**Questionnaire design**

There were three sections of the questionnaire. The first section included questions to determine student demographics such as age and year level, followed by additional questions for Years 10-12 related to mathematics participation and subject selection. The remaining items were presented in sections categorised as general mindset, mindset and mathematics, mindset and English (as a comparison to mathematics) and factors influencing mindset. A comparison between mathematics and English was aiming to shed light on domain-specific processes that may be related to mindset. Many subject areas could have be chosen, however English, as a subject to be studied, did not suffer from students having a fixed mindset, as in mathematics. English was different to mathematics, in that its emphasis was on literacy rather than numeracy. In distinct contrast to mathematics, English required more qualitative rather than quantitative skills. Using English as a comparison sharpened the focus on mathematics. Furthermore, English and mathematics had stereotypically been contrasted by gender stereotyping. For example, Leder et al. (2014) questioned pedestrians on the street regarding their views on the teaching and learning of mathematics and English, for both boys and girls. The researchers found that mathematics was endorsed by many as a male domain, and English as a female domain. Mathematics has traditionally been a masculine stereotyped subject and English has been a more feminine stereotyped subject (Leaper et al., 2012). Given the importance of the English language and numeracy as in mathematics, the questionnaire in this study, explored the mindset of both of these domains. An important question was whether the mindset results for mathematics would be similar or different to the mindset of another subject such as English.
Some items of the questionnaire were drawn from existing scales developed by Dweck. The questionnaire for this study included several questions from the *Implicit Theories of Intelligence Scale for children aged 10 and older* (Dweck, 2000). Reliability and validity data for implicit theory scales are available (see Dweck et al., 1995; Levy, Stroessner & Dweck, 1998). The questionnaire also included other scales derived from factor analysis: mathematics and English engagement, work ethic, peer factors and gender factors. Existing scales were utilised from Dweck (2000), Grant and Dweck (2003), McCrea, Hirt and Milner (2008), and Yeung (2011). Questions relating to mastery and performance goals in achievement and questions pertaining to how students viewed ability and effort were also included. Standardised questions were used so that direct comparisons with other studies could be undertaken. Additional items related to mindset, and that were specific to the school, and Australian context, were also included. These questions were added in order to gain a deeper insight relating to the school-related influences on students’ implicit beliefs of intelligence.

To be faithful to Dweck’s *Implicit Theories of Intelligence Scale*, the word intelligence was not substituted for another term, such as ability, in the questionnaire. Furthermore, De Castella and Byrne (2015) revised a ‘self-theory’ measure of the implicit theories of intelligence scale (*Implicit Theories of Intelligence Scale*) in order to personalise the eight statements for students. For example, instead of the statement “Your intelligence is something about you that you can’t change very much”; De Castella and others’ statement read “My intelligence is something about me that I personally can’t change very much”. The changing of the statements to first person, has the potential to allow students to reflect on their own beliefs rather than generalized beliefs. However, students may be reluctant to present their own beliefs and prefer the statement to remain general. The general format written in third person was utilised in this study.

The questionnaire required participants to demonstrate their degree of agreement with each item on a 4-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). To discourage students from not committing to a definitive belief, choices of ‘mostly agree’ and ‘mostly disagree’ were not included as scale items.

In addition, in order to avoid student fatigue in completing the questionnaire, only four (two entity and two incremental) statements were used, rather than Dweck’s eight statements.
Furthermore, seven statements were included for both mathematics and English intelligence beliefs. There were 53 or 55 items depending on the Year group. Students completed the questionnaire in approximately 20 to 30 minutes. Questionnaire items are located in Appendix B.

**Semi structured Interviews**

In order to layer and complement the quantitative data, interviews were employed as a data collection method. Interviews can access people’s perceptions, meanings, definitions of situations and constructions of reality and is one of the most powerful ways we have of understanding others (Punch, 2005). Interviewing can be structured, semi structured, or unstructured (Fontana & Frey, 2000). There is a continuum, from the structured to the unstructured interview, via the semi structured (Burnard, 2005), which vary in the degree of structure and depth. According to Fontana and Frey (2000), structured interviewing involves the interviewer asking the respondents the same series of pre-established questions with a limited set of response categories. The interviewer controls the pace of the interview according to the script in a standardised and straightforward manner and plays a neutral role, never interjecting with a statement or an opinion to a respondent’s answer. The responses are coded according to a coding scheme that is also pre-established. The data from such interviews are the easiest to process.

At the other end of the scale, unstructured interviews often commence with a broad, open question. This type of interview is very similar to a conversation (Bryman, 2012). According to Burnard (2005), the researcher takes the lead from the respondent and, each interview with each respondent, is likely to be different. There is a greater breadth of data provided given its qualitative nature (Fontana & Frey, 2000). However, the processing of data from unstructured interviews can be both time consuming and difficult.

In this study, the semi structured interview was selected as the most suitable method. Semi-structured interviews allow all participants to be asked the same questions within a flexible framework (Dearnley, 2005). It provides participants with more latitude to respond in their own words, but can also be focused using specific questions in response to a general answer. (Costley, Elliott & Gibbs, 2010). According to Freebody (2003), the semi-structured interview aims to have something of the best of both worlds by establishing “a core of issues to be
covered but at the same time allowing the interviewer free to vary, around and out from that core” (p. 133).

In this study, the same sequence of questions were posed to each student however there was latitude to use further questions to investigate what were seen as significant replies (Bryman, 2012). The strength of coupling a questionnaire and an interview, (O’Toole & Beckett, 2010; Bryman, 2012), was the ability to establish rapport with participants, clarify information gained from the questionnaires and add a deeper, rich understanding of, in this case, student mindset.

Furthermore, McBurney and White (2004), claim that an advantage of using face to face interviews is that the interviewer may be able to notice if, or when, participants misunderstand a question. The interviewer has the opportunity to explain the meaning of the question, or slightly rephrase the question, and probe for more complete answers. The greatest advantage of the interview is that it has the capacity to provide insights into how research participants view and make meaning of their world.

**Interview design and conduct**

The interview schedule was designed in several sections, with interview items corresponding to each of the five research questions. Questions 1 and 2 were general questions so that the student would feel comfortable and relaxed in the interview. Questions 3 to 10 (research questions 1 and 2), promoted a discussion of what students perceived intelligence to be and acted as probes regarding students’ understandings of the concepts of ability and effort in learning, for example ‘What role does intelligence or being smart play in doing well at school’? Questions 13 to 20 and Question 23 (research question 3 and 4), promoted a discussion of mindset and mathematics, relating this to their participation in future mathematics courses, for example, ‘Have your views about how good you are at Maths influenced your Maths choices? Questions 11 to 12 and Questions 21 - 22 (research question 5), explored what influenced students’ beliefs about ability in general and mathematics in particular, for example, ‘In your group of friends is it OK to work hard at school’? ‘Why do they think this’?

The interview was designed to incorporate the key features of sound interview practice: “demographic style opening questions; questions moving from more general to specific; and
easy to more difficult” (Bryman, 2012, p. 476). The questions were not personal or judgemental.

The interview was conducted generally for approximately 20-25 minutes. Interview questions are detailed in the Appendix C. Interviews were digitally recorded and transcribed by a professional transcription company.

A summary of the data collection methods that were used to respond to each research question appear in Table 3.1. Table 3.1 illustrates the questionnaire and interview items matched to the research questions.
### Table 3.1: Summary of data collection methods

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Scaled Questionnaire items</th>
<th>Non-Scaled Questionnaire items</th>
<th>Interview questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What implicit theories of intelligence or mindset do female secondary students hold? In particular, what beliefs do they hold about ability and effort and their roles in academic achievement?</td>
<td><strong>General growth mindset scale</strong> (4 items)</td>
<td>Q44 I like my work best when it makes me think hard.</td>
<td>Q1 What are your favourite subjects and what do you like about them?</td>
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<td></td>
<td>Q1 You can always greatly change your intelligence. Q14R You have a certain amount of intelligence and you really can’t do much to change it.</td>
<td>Q2R I like my work best when I can do it really well without too much trouble.</td>
<td>Q2 Do you find some subjects easier than others? Which ones do you find easier? Why do you think that is?</td>
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<td></td>
<td>Q35 No matter how much intelligence you have, you can always change it quite a bit. Q50R You can learn new things, but you can’t really change your basic intelligence.</td>
<td>Q7 I like work that I learn from even if I make a lot of mistakes.</td>
<td>Q3 Why do some people do better at school than others?</td>
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<td></td>
<td><strong>Work ethic scale</strong> (9 items): Q3 I pride myself in being a hard worker at school. Q8R I don’t ask for help because it makes me look dumb. Q24R I only try hard if a task counts towards my final grade. Q26R I am mainly interested in the marks I get, not the teachers’ comments on my work. Q32 I am proud to admit how hard I work at school to other people. Q37 My grades are the result of effort and hard work;</td>
<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q4a What does the word intelligence mean to you at school?</td>
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<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q4b What does the work effort mean to you at school?</td>
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<td>Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q5a What role does effort or work play in doing well at school?</td>
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<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
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<td>Q5b What role does intelligence or being smart play in doing well at school?</td>
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<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q5c Is one more important than the other?</td>
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<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
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<td>Q5d Can you give a percentage to each?</td>
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<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q6a If somebody studies a lot; will they become more intelligent?</td>
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<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q6b Does working harder mean that they will get smarter?</td>
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<td></td>
<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q7 Do you think that you work hard at school? Can you tell me a bit more about that? What does working hard involve?</td>
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<td></td>
<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q8 In your normal school day is there anything that helps you work hard or make an effort?</td>
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<tr>
<td></td>
<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q9 What things stop you from making an effort or working hard at your school work?</td>
</tr>
<tr>
<td></td>
<td>Q4 If I fail an assignment, I should be able to keep working on it until I pass. Q12 Grades should be based in part on how much effort you put into an assignment task. Q17 I think that students who keep trying, even in the face of failure, should be admired. Q22R I like my work best when I can do it perfectly without any mistakes.</td>
<td>Q7 If I fail an assignment, I should be able to keep working on it until I pass.</td>
<td>Q10 Would you rather be thought of as smart or hard working? What are your reasons for this?</td>
</tr>
</tbody>
</table>
Q39R I tend only to work as hard as I have to in my classes. Q43R If I think that I am not good at something then I don’t even try. Q20R I would rather be admired for my ability than for my hard work at school.

**Looking smart scale** (2 items) Q27 I would rather be thought of as smart as hard working. Q49 It is important to me that I look smart compared to others in my class.

3. What implicit theories of intelligence specifically related to mathematics do female secondary students hold?

**Mathematics Growth Mindset scale** (7 items) Q9R You have a certain amount of ability in Maths, and you can’t really do much to change it. Q19R You can learn new things but you can’t really change your ability in Maths. Q23R To tell the truth, when I work hard in Maths if makes me feel as though I’m not very smart. Q31 Anyone can be excellent at Maths if they work at it. Q34R To do really well in Maths you must be naturally good at it. Q34R To do really well in Maths you must be naturally good at it. Q45 You can always greatly change your ability in Maths. Q48 No matter how much Maths ability you have, you can always change it quite a bit.

Comparison to English: **English Growth Mindset scale** (7 items) Q11 No matter how much ability in English you have, you can always change it quite a bit. Q21R You have a certain amount of ability in English, and you really can’t do much to change it. Q25 You can always greatly change your ability in English.

Q14. Do you like Maths? Why?
Q15. Do you do well at Maths? Why is that?
Q16. Do you think Maths is an easy or difficult subject? Why do you think this?
Q17. What do you find easy or difficult about it?
Q18. Is Maths harder or easier than other subjects?
Q19. Can someone get better at Maths? How could they do this?
Q20. Do you think that being good at Maths is something you’re born with or do you develop it over time? Why?
Anyone can be excellent in English if they work at it. Q47 To do really well in English you must be naturally good at it. Q51 To tell the truth, when I work hard in English, it makes me feel as though I’m not very smart. Q38 You can learn new things, but you can’t really change your ability in English.

4. What is the relationship between these beliefs and their participation in mathematics?

<table>
<thead>
<tr>
<th>Maths engagement scale (4 items)</th>
<th>Question 54 Participation in Senior Mathematics’ courses (non-compulsory).</th>
<th>Question 55 Choice of Mathematics courses at the senior level.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5 I enjoy Maths classes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q29 I feel that I belong in a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maths class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q36 I am interested in Maths.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q52 I try hard in Maths.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison to English.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English engagement scale (4 items)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6 I try hard in English.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q16 I feel that I belong in an</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q18 I am interested in English.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q33 I enjoy English classes.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. What are students’ perceptions of the factors influencing their beliefs about intelligence in general and ability in mathematics in particular?

<table>
<thead>
<tr>
<th>Peer factors scale (2 items)</th>
<th>Q15 Maths is a difficult subject.</th>
<th>Q28 English is a difficult subject.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q40 In this school, students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>who try hard are teased.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q46 It’s not cool in my group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of friends to try hard in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender factors (2 items)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q13 Girls have more natural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ability in English than boys.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q41 Boys have more natural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ability in Maths than girls.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Q11. In this school who is     | Q11. In this school who is        | Q12. In your group of friends is   |
| respected more, students who  | respected more, students who are  | it OK to work hard at school? Why   |
| are smart or students who work | are smart or students who work     | do they think this?                 |
| hard? Can you tell me a bit   | hard? Can you tell me a bit more   | Q21. Do you think girls and boys   |
| about that? Q12. In your group | about that? Q12. In your group of  | are equally good at Maths? Why?     |
| of friends is it OK to work    | friends is it OK to work hard at    | Q22. What influenced your decision  |
| hard at school? Why do they    | school? Why do they think this?     | to take or not take Maths in Years  |
| think this? Q21. Do you think  | Q22. What influenced your decision  | 11 and 12?                         |
| girls and boys are equally    | to take or not take Maths in Years  |                                  |
| good at Maths? Why? Q22. What  | 11 and 12?                         |                                  |
Data Analysis

Quantitative data.

Data analysis in this study required the application of multiple statistical analyses. Punch (2005) uses a three stage process for such analyses: i) a simple descriptive analysis (e.g. mean, SD); ii) two-variable relationships (t-tests); and iii) multivariate relationships (ANOVA) which together provide a useful analytic framework. In this study, quantitative data were analysed using the IBM Statistical Package for the Social Sciences (SPSS v24). The software is a comprehensive package which can perform highly complex data manipulation and analysis.

In a quantitative study, internal reliability is essential. Internal reliability is defined by Bryman (2012), as “the degree to which the indicators that make up a scale are consistent” (p. 712). According to Punch (2005), the internal consistency of a measuring instrument concerns “the extent to which the items in the questionnaire are consistent with each other or all working in the same direction” (p. 95). Factor analysis was used in this study to establish sub-scales within the questionnaire. Mertens (2015) describes factor analysis as “an empirical way to reduce the number of variables by grouping those that correlate highly with each other” (p. 174).

From the questionnaire, 41 items were subjected to principal components analysis (PCA) using SPSS v 24. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of coefficients of .2 and above. The Kaiser-Meyer-Olkin value was .906, exceeding the recommended value of .6 and Bartlett’s Test of Sphericity reached statistical significance, supporting the factorability of the correlation matrix (Pallant, 2011).

Principal components analysis revealed the presence of nine components with eigenvalues exceeding 1, explaining 25.5%, 7.8%, 6.1%, 5.1%, 3.8%, 3.5%, 3.3%, 3.0% and 2.8% of the variance respectively. An inspection of the scree plot revealed a clear large break between component 1 and 2, then a series of small breaks or changes up to the ninth component which verified the principal components analysis. To aid in the interpretation of these nine components, oblimin rotation was performed. All components showed strong loadings and most variables loaded substantially on only one component with the exception of five variables; Question 6,
Question 24, Question 43, Question 21 and Question 20. The results of this analysis support the use of nine separate scales. The statistical analyses; the total variance explained, the scree plot, pattern matrix and structure matrix are included in Appendix D.

Mindset questions have been the subject of considerable research and development. The three groups of mindset questions (general, mathematics and English) formed three distinct scales. Other items formed six separate scales such as work ethic, engagement in mathematics, engagement in English, looking smart (performance) factors, gender factors and peer factors. The reliability of these scales were assessed. Other items were analysed individually, such as Question 15 - mathematics is a difficult subject. Items assessing learning behaviour were more exploratory in nature. Scale reliability as measured by Cronbach’s alpha appears in Table 3.2.

**Table 3.2: Scale reliability**

<table>
<thead>
<tr>
<th>Scales</th>
<th>Number of items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>General growth mindset</td>
<td>4</td>
<td>0.74</td>
</tr>
<tr>
<td>Mathematics growth mindset</td>
<td>7</td>
<td>0.85</td>
</tr>
<tr>
<td>English growth mindset</td>
<td>7</td>
<td>0.83</td>
</tr>
<tr>
<td>Work ethic</td>
<td>9</td>
<td>0.74</td>
</tr>
<tr>
<td>Mathematics engagement</td>
<td>4</td>
<td>0.85</td>
</tr>
<tr>
<td>English engagement</td>
<td>4</td>
<td>0.83</td>
</tr>
<tr>
<td>Looking smart (performance)</td>
<td>2</td>
<td>0.52</td>
</tr>
<tr>
<td>Gender factors</td>
<td>2</td>
<td>0.57</td>
</tr>
<tr>
<td>Peer pressure factors</td>
<td>2</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Three scales; looking smart, gender and peer pressure had only two items. Eisinga, te Grotenhuis and Pelzer (2012) discussed the reliability of a two-item scale. The researchers argued that the use of “multiple, heterogeneous indicators enhances construct validity in that it increases the likelihood of adequately identifying the construct of interest” (p. 2). However, they recognised questionnaire time constraints and the need to limit the number of questions asked of participants was a factor for consideration. Eisinga et al. (2012) advocate the use of the Spearman – Brown formula to estimate the reliability of two item scales. Determining the strength of the
relationship has different interpretations. Pallant (2011) suggests the following guidelines; small $r = .10$ to .29; medium $r = .30$ to .49 and large $r = .50$ to 1.0. The statistics for the two item scales appear in Table 3.3, Table 3.4 and Table 3.5.

Table 3.3: Correlation of looking smart statements

<table>
<thead>
<tr>
<th></th>
<th>Correlation Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>N</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spearman's rho</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.I would rather be thought of as smart than hard working</td>
<td>.35**</td>
<td>.00</td>
<td>489</td>
<td>487</td>
</tr>
<tr>
<td>49.It is important to me that I look smart compared to others in my class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

As illustrated in Table 3.3 there was a medium, positive significant correlation between the two looking smart (performance) statements. A correlation of $r = .35$, means 12% shared variance ($\text{.35} \times \text{.35} = .12$)
Table 3.4: Correlation of gender stereotype statements

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>41. Boys have more natural ability in Maths than girls</th>
<th>Correlation Coefficient</th>
<th>1.00</th>
<th>0.43**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td>484</td>
<td>479</td>
</tr>
<tr>
<td>13. Girls have more natural ability in English than boys</td>
<td>Correlation Coefficient</td>
<td>.43**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.00</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td>479</td>
<td>484</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

As illustrated in Table 3.4 there was a medium, positive significant correlation between the two gender stereotype statements. A correlation of .43, means 18% shared variance (.43 x .43 = .18)

Table 3.5 Correlation of peer pressure statements

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>46. It's not cool in my group of friends to try hard in class</th>
<th>Correlation Coefficient</th>
<th>1.00</th>
<th>0.46**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td>488</td>
<td>487</td>
</tr>
<tr>
<td>40. In this school, students who try hard are teased</td>
<td>Correlation Coefficient</td>
<td>.46**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.00</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td>487</td>
<td>489</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
As illustrated in Table 3.5 there was a medium positive significant relationship between the two peer pressure statements. A correlation of .46, means 21% shared variance (.46 x .46 = .21). From these calculations it was deduced that the scales were reliable for the construct being measured.

The analysis of the questionnaire data allowed me to explore mindset in general and to make comparisons with beliefs about ability in mathematics and English. Dweck (2000) did not correlate implicit theory scales with other scales, for example, cognitive abilities as she makes the point that “implicit theories represent assumptions about the self that have cognitive, motivational, emotional and behavioural consequences but they are distinct from other cognitive and motivational constructs” (p. 176). In this study, correlations were undertaken to explore the relationships between the different scales listed in Table 3.2, in order to discuss students’ motivation in mathematics and possible behavioural consequences.

**Interview analysis.**

Qualitative data analysis is often known as ‘thick data’ because it is complex and textured (O’Toole & Beckett, 2010, p. 170). Yin (2010, p. 178) describes the five phases of analysis of qualitative data as compiling, disassembling, reassembling, interpreting and concluding. According to Yin, these phases of the analytic process do not form a linear sequence but rather have recursive and iterative interactions.

The first phase of analysis, *Compiling*, involves methodically organising the original data and creating a database, or orderly set of records (Yin, 2010). In relation to this study, compiling the data involved gathering and organising the transcripts of the individual student interviews. Once all the original data were compiled, in a database, an electronic file, the second phase of the cycle began.

The second phase of the analytic cycle is *disassembling* the data in the database (Yin, 2010). Disassembling the compiled data involves breaking it down into smaller pieces or fragments and may be repeated numerous times. After the interviews were digitally recorded, they were transcribed and the range of possible responses for each question was identified. Similar
responses were assigned codes (colours corresponded to codes). Computer software was not used in analysis of the qualitative data.

The third phase of Yin’s (2010) qualitative analysis, is a Reassembling procedure. The researcher can discover emerging patterns in the data which has been disassembled. Reassembling the data into broad categories or themes. This was an inductive analysis approach or thematic analysis (Bryman, 2012, p. 580). Student responses to questions were multi-dimensional and encompassed several major themes. Thomas (2006) recommends three to eight themes that capture the key aspects identified in the raw data from each interview question and are assessed to be the most important themes, given the objectives of the research. Research supervisors undertook theme consistency and clarity checks using an independent parallel coding process. Yin (2010) points out that the reassembled data can be depicted graphically, arranged in lists, or in other tabular forms. From these emerging patterns and themes, the data can then be interpreted. In relation to this study the data were categorised and compiled as evidenced in the results chapters’ tables.

The fourth phase of analysis involves Interpreting the reassembled data (Yin, 2010). According to Yin, the interpreting phases of qualitative data analysis involves the researcher giving meaning to the reassembled data and data arrays. The themes identified provided me with the basis for a prosing a theoretical contribution to the research literature on mindset.

The final analytic phase within the cycle is Concluding. The researcher presents the main data or empirical findings and draws conclusions from the entire study to highlight the broader significance of the research (Yin, 2010). The inferences made, on the basis of both the qualitative and quantitative results, can then be drawn together to form meta-inferences at the conclusion of the study. This process assists in deepening the conceptual level of the study providing implications of the study.
## Table 3.6 Relationship between research questions, data collection and analyses

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Student questionnaire</td>
<td><strong>General growth mindset scale</strong>&lt;br&gt;Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Student questionnaire</td>
<td><strong>Work ethic scale; Looking smart scale</strong>&lt;br&gt;<strong>Pearson’s correlation coefficient for:</strong> general growth mindset and work ethic; general growth mindset and looking smart&lt;br&gt;Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Student questionnaire</td>
<td><strong>Mathematics growth mindset scale</strong>&lt;br&gt;<strong>English growth mindset scale</strong>&lt;br&gt;<strong>One way repeated measures ANOVA</strong> to compare general, mathematics and English growth mindset&lt;br&gt;Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Student questionnaire</td>
<td><strong>Independent samples t-test:</strong>&lt;br&gt;1. Mathematics growth mindset and mathematics participation in Years 11 and 12&lt;br&gt;2. General growth mindset and mathematics participation in Years 11 and 12&lt;br&gt;3. Mathematics engagement scale with mathematics course selection in Years 11 and 12&lt;br&gt;<strong>Pearson’s correlation coefficients:</strong>&lt;br&gt;Mindset scales with mathematics engagement scale&lt;br&gt;<strong>Mathematics course selection</strong> (students in Years 10, 11 and 12)&lt;br&gt;Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Student questionnaire</td>
<td><strong>Paired sample t-Tests</strong> (Mathematics is a difficult subject and English is a difficult subject)&lt;br&gt;Pearson’s correlation coefficients:&lt;br&gt;1. Mathematics is a difficult subject with mindset scales.&lt;br&gt;2. English is a difficult subject with mindset scales&lt;br&gt;3. Gender stereotype scale with mindset scales&lt;br&gt;4. Peer pressure scale with mindset scales&lt;br&gt;Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>Student interviews</td>
<td></td>
</tr>
</tbody>
</table>
Credibility of the Study

To support the trustworthiness and creditability of this research, I employed strategies to increase both the internal and external validity of the data. Bryman (2012) defines internal validity as “a concern with the question of whether a finding that incorporates a causal relationship between two or more variables is sound” (p. 712). Internal validity of this research was strengthened as a result of:

- the use of multiple methods (both qualitative and quantitative paradigms);
- the collection of data using a range of instruments, (questionnaire and semi-structured interviews);
- the selection of an appropriate sample (487 students completed the questionnaire and a subset of 45 students were interviewed);
- university supervisors checking interview transcripts and themes; and
- triangulation of data.

Triangulation.

Triangulation occurs when quantitative methods which provide reliable results are combined with qualitative methods to produce results rich in meaning. Bryman (2012) defines triangulation as “the use of more than one method or source of data in the study of a social phenomenon so that findings may be cross-checked” (p. 717). According to Liamputtong (2013), the most powerful means for strengthening creditability in qualitative research is triangulation. The word is derived from land surveying and navigation, where it refers to the use of two landmarks to calculate the accurate location of the third. In research design, “it is based on the convergence of information from multiple sources to corroborate the data and evolving themes” (p. 30).

Furthermore, O’Toole and Beckett (2010) point out that triangulation just means that “data or inferences corroborated from at least two other independent angles are logically three times as likely to be true as uncorroborated data” (p. 33). In addition, according to Denzin and Lincoln (2005), “triangulation as a strategy adds to the rigour, breadth, complexity, richness and depth to any enquiry” (p. 5). Cho and Trent (2006) in summarising the importance of triangulation note
that it “will lead to a more consistent, objective picture of reality and if used with caution can enhance the creditability of a research account by providing another way of generating evidence in support of the research questions” (p. 323). Multiple methods were used in this study; a questionnaire and semi-structured interviews to validate my findings. The interviews exposed different perspectives of student reality.

**External validity.**

External validity refers to the degree to which the findings of the research can be generalised to other groups, cases or populations. Bryman (2012) defines external validity as “a concern with the question of whether the results of a study can be generalised beyond the specific research context in which it was conducted” (p. 711). Readers of this study can draw broader conclusions based on their own contexts and student demographics (Stake, 2000).

**Method Summary**

Mindset offers a useful way of understanding motivation and expectations related to mathematics participation and achievement in relation to gender. There has been little research connecting these themes. As discussed earlier, most of the previous studies on mindset have been quantitative in nature and have relied solely on fixed choice questionnaires, indeed many have been conducted in a laboratory type-setting, using ‘single-shot’ interventions. Overall these studies lack the ecological validity of a naturalistic study. A qualitative approach, which allows the students to explain their views in some detail and within the context of their everyday school life, is also lacking in the reviewed research. This gap in the research literature was addressed in this study as I sought a detailed and more nuanced understanding of mindset and how it impacted on students’ motivation and achievement.

**Ethical Considerations**

This section addresses the ethical considerations associated with the study. There were a number of specific ethical matters that needed to be considered in relation to the research: conducting research with young people under 18 and conducting research with people in dependent or unequal relationships. As part of this consideration, the processes for gaining participant consent
and maintaining confidentiality and anonymity are described. This section will also document ways the integrity and trustworthiness of the research given my own role in the school was ensured.

Research with young people under 18.

All participants in the study were 18 or under. Consent to participate was sought from parents/guardians and the students by providing an information sheet (questionnaire) and a letter (interview) (Appendix A: 3 & 4).

Consent procedure for the questionnaire.

The following procedures were applied to gain consent from students and their parents/carers to complete the questionnaire. An information sheet regarding the research was sent to all parent/s and carers. Parents were asked to inform the school if they did not wish their daughter to complete the questionnaire (opt-out consent).

The research was explained to students at Year level meetings and an information sheet was provided to students by the Year Coordinators. The act of the student completing the questionnaire was taken as consent. If students (or their parents) did not wish to complete the questionnaire then an alternate activity was offered during the class time in which the questionnaire was administered.

Consent procedure for the interview.

Active consent from both parents and students was sought for interview participation. Students were invited to participate in the interview at form assemblies by their Year Coordinators. If students accepted the invitation they were provided with an information sheet and consent form for their parent/carer and themselves. Students were advised that their participation or non-participation in the research would not affect their standing in the school, or the assessment of their work in any way. Students were also advised that if they changed their mind about taking part, even after the study had started, any identifiable information already collected about them would be destroyed.
Students and parents were assured that the questionnaire and the interview were not in any way evaluative of their academic progress or personal in nature. Furthermore, it was important to communicate to potential participants, and to the school community more broadly, that the study was not evaluating the school, the staff nor the students and their peers. The students were advised to consult their Year Coordinator or School Counsellor if there was any concern with the study.

Anonymity and Confidentiality

There were a variety of methods employed to ensure student anonymity during and after the study. The questionnaire was anonymous, as students were not required to identify themselves by name. Questionnaire data were aggregated, and as a result no individual students could be identified. In regard to the data arising from the interviews with students, a pseudonym was assigned before analysis, and used in the recording and reporting of results. Interviews were digitally recorded and all records of interviews (audio and transcriptions) were kept confidential, by use of password protected computer access, and were available only to the researcher and her supervisors. The name of the school will not appear in any published results from the study. However, given my former role in the school and also the location of the school in a regional town, the school may be identifiable. This detail was made clear to parents and students in the information sheet.

My role as principal and as researcher

Research context and role of the researcher.

As School Principal in the study school, my role offered a breadth of insider knowledge and convenience for data collection. However, my role in the school raised a number of ethical and methodological questions. There is relatively little in the literature about researchers who conduct research in their own organisation (Lovat, 2003; Miller, 2002; Nicotera, 1999), especially researchers who are ‘insiders’ before, during and after the research has been carried out (DeLyser, 2001). Evered and Louis (1981) argue that an enquiry from the inside is likely to yield knowledge that is inherently more valid, useful and relevant to the purposes of the participants.
Further, they point out that inquiries from the outside, make a more detached researcher in conducting studies, but may make the research findings less pertinent for the study. Inquiry from the inside carries with it the assumption that the researcher can best come to know the reality of an organization by being there. A school researcher, as an insider, is better able to bring the project to life, has a more nuanced understanding of the school and can identify strategies for successful implementation. Researchers who examine their own organisation can offer a unique perspective because of their knowledge of the culture, history and people involved (Dearnley, 2005). There is the danger, however, that the findings could be distorted and contaminated by the values and purposes of the researcher.

Trustworthiness of the research.

As Principal, I was an insider in the research and as such, needed to demonstrate to the research community that the findings were trustworthy. In such cases, it is important for the researcher to minimise any possible bias and be as objective as possible. Strategies to minimise bias in this study included gathering two sources of data, using a questionnaire that used existing and validated items, and careful design of open-ended interview questions that avoided leading questions. To avoid bias in data analysis, data were reviewed by my thesis supervisors.

As an additional safeguard to ensure the trustworthiness of the study, an external critical panel was established, called the “Lumiere Committee” (School motto - be a light to the world). The idea for this committee was based on the work of Degenhardt (2006), a Principal who conducted research in her own school and established a similar committee to ensure the integrity of her research. A panel of two external experts, was formed as a major means of safeguarding the research against possible claims of bias emanating from my former position within the school. This panel was established in order to incorporate ‘outsider’ views into the research as a balance to the ‘insider’ views of the researcher. As Costley et al. (2010) point out, to avoid any subjectivity it is important to call on others to verify or contest accounts. The panel comprised a principal of a neighbouring primary school who was also a chairperson on a private secondary school board and a secondary schools’ consultant at the Catholic Education Office. This group met with me at the commencement of the research, during the data gathering phase and during the data analysis.
phase. There were four meetings in total. The group were a sounding board for the study and were able to offer a detached view of the integrity of the research methodology and ethical conduct of the research. Any disagreements between this external panel and the researcher/principal were referred to the latter’s thesis supervisors.

My specific insider role in the school also posed methodological questions. My position posed both advantages and disadvantages in regard to student comfort. I was known to the students, and many were comfortable conversing with me as I chatted with them in the school playground. However, my position, also posed the threat of an unequal relationship. The research was consciously designed to ensure that students were not coerced into participation, were thoroughly informed of the nature and purpose of the study, and were fully aware of the requirements of consent.

It was important to establish rapport with each student who consented to be interviewed and ensure that they were relaxed in my presence. The interview was entirely voluntary in nature (active consent) and the questions asked were non-evaluative and non-personal. I was overtly aware of the importance of reassuring each student about the nature of the questions.

In terms of the selection and recruitment of participants, the methods employed to collect and analyse data were carefully considered in relation to my role in the school.

**Dependent and unequal relationship.**

There is an unequal power relationship between school students and their school principal. In this study, participation was invitational and actions were employed to ensure that students did not feel coerced. To ensure that students did not feel coerced to participate in the research, the questionnaire was distributed in classes by teachers other than myself. The students were also invited to participate in the interview at a form assembly, where I was not present. Further measures to ensure students were not coerced included requiring written consent from parent/carer, as well as from the individual student, prior to participation in the interview. Students were also informed that participation or non-participation would not affect their standing in the school in any way and that they could withdraw from the study at any time without any penalty or repercussions for their progress at school.
Given my role as principal and the dependent relationship between principal and students, I established an internal school committee consisting of the six Year Coordinators and the School Counsellor to act in the role of ‘ombudsman’ for the school community in the event that students or parents had a concern with aspects of the research. The Year Coordinators and the Counsellor have significant roles in the pastoral and welfare needs of students. Students were invited to raise any concerns related to the research with the Counsellor or Year Coordinators. The concerns of students and parents would be treated in confidence and the matter would be raised with either with myself or the University Ethics officer. At all times there was an ethic of care. Costley et al. (2010) define this as:

A form of existential trust that transcends the social roles bestowed by others. Participants offer up their vulnerability, revealing themselves in their authenticity stripped of the protection of these roles. It is involving not observational. When we care for an individual, we care for them as part of being as a whole, thus recognising all beings in harmony and so becoming authentic ourselves. Caring carries a moral obligation. (p. 43)

**Ethics Approval**

Ethics approval was gained from the Charles Sturt University Ethics in Human Research Committee and the Catholic Education Office of the Bathurst Diocese (Appendix E).
Chapter Four: Results

Implicit Theories of Intelligence (Mindset)

Introduction

Chapter Four is the first of the three results chapters and presents the findings related to the following research questions:

1. What implicit theories of intelligence or mindset do female secondary students hold? In particular, what beliefs do they hold about ability and effort and their roles in academic achievement?
2. What is the relationship between these beliefs and students’ self-reported learning behaviours?

The research questions act as organisers for the presentation of results from the data analysis. The data for this chapter were derived from an analysis of two sources:

i) students’ responses to the “Mathematics and Mindset” Questionnaire; and
ii) face to face interviews with a subset of 45 students from the sample, aged from 12 to 17 years.

As described in Chapter Three, 487 female students from the selected secondary school in the NSW Central West, completed the Mathematics and Mindset questionnaire. As previously defined in the literature review, a growth mindset is the belief that intelligence can be developed and is malleable.

Firstly, the findings from the questionnaire and interview assisted in identifying students’ general intelligence mindset by examining the scales and interview responses for:

- the general growth mindset scale (school sample);
- implicit theories of intelligence (subset of interviewed students);
- the work ethic scale and looking smart scale (school sample); and
• implicit theories of intelligence and self-reported learning behaviours (subset of interviewed students).

The findings from the questionnaire follow.

**General Growth Mindset Scale**

Four questionnaire items formed the general growth mindset scale. The summary statistics appear in Table 4.1.

**Table 4.1: Summary statistics for general growth mindset**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth mindset</td>
<td>482</td>
<td>12.00</td>
<td>4.00</td>
<td>16.00</td>
<td>12.05</td>
<td>2.05</td>
<td>4.22</td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td>482</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Twenty eight students (5.8%) scored the maximum 16 and one student (0.2%) the minimum score of 4. A fixed mindset was indicated by 4.7% of students scoring 8 or below. In comparison, 66.4% of students scored 12 or above, indicating an overall agreement with general growth oriented statements.

**General Intelligence Mindset (implicit beliefs)**

The student interviews revealed the different meanings that students assign to the word intelligence. For some students the term may have been quite ambiguous and this ambiguity may have led to some confusion in selecting a response in the questionnaire. Interview responses in general, supported the quantitative findings of the questionnaire. The student interview responses indicated complex and varied implicit beliefs about intelligence. Three major themes emerged from the data analysis each with sub-themes.

There were various implicit beliefs of intelligence:

- a growth mindset linking effort to growth in intelligence;
a growth mindset but only for school achievement (improved results) with no growth in intelligence (remains fixed); and

a fixed mindset such that ability or intelligence was innate and unchangeable.

The beliefs had three main variations:

- what amount of intelligence was innate versus the amount which could be developed;
- what percentage of growth in intelligence was possible e.g. limitless vs. capped; and
- there was more than one type of intelligence (multiple intelligences).

How effort was viewed depended on the student’s implicit beliefs about intelligence. Students held two distinct beliefs relating to effort:

- effort was necessary to develop intelligence (positive); and
- effort was compensatory for a lack of intelligence (inverse or deficit model).

Each of these three major themes will be elaborated.

**Implicit beliefs of intelligence (mindsets).**

When asked the meaning and role of “intelligence” the students’ responses were varied. As evidenced by students’ brief and cautious responses, students found it difficult to speak about intelligence. The three most popular definitions of intelligence were i) being smart and/or capable (36%); ii) being a hard worker/trying hard (29%); and iii) understanding school subjects (22%). Three students could not describe the role of intelligence. Jessica8, replied that “it was a hard question”; Kay11 said “I really have no idea” and Elizabeth10 acknowledged that “she was not sure”. Intelligence was perhaps a slippery concept for most to define or describe.

Mueller and Dweck (unpublished data, cited in Dweck, 2000 p. 61), found that College students with an entity or fixed mindset, significantly more often defined intelligence as a person’s inherent capacity or potential and ruled out effort or motivation as part of intelligence. In contrast, students with an incremental or growth mindset defined intelligence as a person’s skills and knowledge and explicitly included effort and motivation as integral parts of intelligence.

Mueller and Dweck’s research findings, indicated that 47% of students were more entity theorists (fixed mindset), 33% were incremental theorists (growth mindset) and 20% of student responses
indicated a mix of both theories. Dweck (2000, p. 7), reports that for each specific domain the number of people who show a helpless entity response and those who show a mastery-oriented incremental response is approximately equal, with a small group (approx. 15%) who don’t fit into either group.

In this study, the majority of interviewed students (93%) reported complex and mixed implicit beliefs of intelligence. Students’ responses were mixed such that their statements contained elements of both fixed and growth mindset beliefs. Students spoke about “intellect”, “potential” and “capacity” but also in the same response spoke about the need for hard work or effort. Very few students unequivocally had completely fixed or completely growth beliefs.

As in Asian cultures, students saw effort as being a major and integral part of intelligence. Most students who gave a mixed or blended response to the definition of intelligence emphasised a person’s potential and recognised the role of effort in developing intelligence. It was not a clear cut entity or incremental view. For example:

Intelligence is maybe getting something naturally, just clicking with explanations but also you can be intelligent if you’re smart enough to know you have to try hard to get through and then you can get good results from that. (Cassandra11)

Intelligence was perceived by most students as being linked to school performance, grades and results, not to developing the brain. Olivia’s interview response exemplifies this belief as follows:

How well they do in the subject, the grades they get. (Olivia11)

Only three students defined intelligence by its relationship to actual brain function as follows:

The level at which your brain can function. (Marlene8)

How your brain probably interprets things and everything. (Margaret8)

Like how your brain works I guess. Like some people have really focused minds and know what they are talking about. (Kay11)

These beliefs are explained in the following section.
Developmental growth mindset (incremental view).

As expressed by the belief that intelligence can be developed, that is, it can be cultivated through learning, Marlene shared her views:

If you’re constantly going over things or learning about new things, your brain is growing and intelligence is about your brain growing. I don’t know a lot about brains but the neurons and electrons maybe get more switched on. Because if you’re working hard you’re obviously exercising your brain, you might discover new things, and that’s again growth. And I think, if you work hard, which is, it’s sort of like effort, I think, working hard can help your intelligence grow. (Marlene8)

Growth mindset but only in relation to school achievement not intelligence (fixed or unchangeable).

Bronwyn and Anastasia believed that effort improved their school results (achievement) but did not necessarily make them more intelligent. The students expressed this belief in the following examples:

I think that if you study a lot you will become better at your study skills and how you work, I don’t always believe that will make you smarter or intelligent, but it certainly plays a role in it for if you were to study for lots of tests, your grades would be higher. (Bronwyn10)

If someone spends all their time studying, reading through textbooks, writing down notes, sure you’re going to pick up stuff but it’s not going to make you more intelligent or anything. (Anastasis8)

Fixed mindset (entity view).

Madison had a contrasting view of intelligence, expressing that intelligence was innate and could not be altered – a fixed belief. The belief that we have a “certain amount of intelligence that dwells within us and that we can’t change” (Dweck, 2000 p. 2). She also pointed out that “if you are smart then you get most of the concepts easily and you don’t have to work as hard to understand”. Madison elaborated on her mindset picture:
Intelligence it’s kind of like what you’re good at, what comes naturally to you. My mum was a really good artist and I guess I have inherited some of her qualities, and I’ve been doing well in Art. My dad’s a mathematician so I’ve been doing well in Maths as well. So I think that I’ve inherited, and it goes towards my other sister as well. Well, I have friends who I know and they try a lot but they haven’t reached their goals, like they just can’t do it. (Madison10)

Madison added that everyone can work hard but not everyone is smart, so it is an advantage to be smart.

I think people think that smart’s more dominating, like “Oh, they’re really smart, they must be really good.” And then hardworking, well, everyone can achieve that, like a prioritising thing. (Madison10)

The students who believed that intelligence was innate raised the concepts of control and choice as issues relating to intelligence and effort. They proposed that working hard was a choice over which there was control, however, being smart was associated with innate ability over which there was no control. The consequences of this belief, that they have no control over intelligence, and that it is not malleable, is indicative of a fixed mindset. Lavinia and Wendy demonstrate the control and choice differentiation for effort and intelligence.

Well you can’t really help your intelligence but you can increase your effort. (Lavinia8)

Because anyone could be smart, I guess, some people are just born smart or whatever, but hard working is something that anyone can do. (Wendy11)

**Variations in student beliefs about intelligence.**

Overlaying these main implicit beliefs of intelligence were three other belief variations. Student responses provided insights into the understanding of the variations in adolescent implicit beliefs of intelligence.
Innate versus developed intelligence.

There were a variety of beliefs regarding the proportion of intelligence which was innate and the proportion of intelligence which could be developed from a baseline. Several students believed that intelligence could be totally developed with no recognition of innateness. This belief was expressed by both Jackie and Meredith:

- People can’t tell you to be smart; you learn to be smart, like as long as you’re hard working you will become smart. (Jackie7)
- Almost anyone can be smart, in that, you know, your brain can grow if you do more things. (Meredith11)

Other students believed that intelligence had a genetic or innate component which could then be developed through learning and life experiences. How much intelligence was innate and how much it could be developed varied along a belief continuum. On average, interviewed students proposed that 38% of their school achievement was based on intelligence and 62% on effort. Individual student responses relating to questions regarding intelligence and effort necessary for academic achievement, varied from 10% to 90% and vice versa. These results have implications for student learning behaviours. These findings are illustrated by the following students’ quotes:

- I think you can improve your intelligence but you have a basis of intelligence that you have to start off with. People have lots of different levels of intelligence but I think you can always improve it. (Sandra11)
- Well I can’t determine how smart I am, or like my natural intelligence. Genetics has a large role in determining that. However I can choose my future and how I wish to put effort into school. A persons’ level of ability which they can then determine how it changes. Like it’s a level of the ability, which the person can further expand. (Melanie11)

Limited growth in intelligence.

Some students had the notion of a ‘ceiling’ or ‘cap’ on their growth of intelligence as illustrated by Eileen:
I suppose it depends on what situation you’re in. If you’re working hard on a subject, then you should see a better result. But sometimes you might just reach your limit, where that subject’s just not for you. I can give you a very good example of that, which is science. No matter how hard I work, I’ll always be in that 70% mark. (Eileen10)

Eileen would seem to have a growth mindset, however she imposed limits on how much she could improve her results. Her response suggests that people can only improve to the fixed limit of their intelligence. People have different ceilings of accomplishment based on how much intelligence they possess. Eileen’s response illustrates a limited growth belief with fixed intellectual potential. A belief that lies somewhere between a growth and fixed mindset but possibly more the latter. This artificial limit that the student perceives as reality may be the point at which their work becomes too difficult and challenging; a point at which effort may seem futile.

**Multiple intelligences.**

Not all students accepted one generic form of intelligence with responses indicating familiarity with Gardner’s Theory of Multiple intelligences (1983). Lavinia expressed the notion of multiple intelligences as follows:

If you have some intelligence then it does help. But if you’re really creative then you might have more an imaginative mind than a smart mind. Some people might be really good at more the academic subjects and some people might be really good at sport and then some people might be really good with the creative bit, they need a bit of creativity like art, music and drama. You do need a bit of intelligence for all of them. (Lavinia8)

The belief in multiple intelligences may also be a limiting belief on full academic potential. A reliance on learning styles may encourage fixed intelligence beliefs.

**Mindset and effort beliefs.**

Whether effort is viewed in a positive growth or negative deficit way depends on the person’s implicit beliefs of intelligence. Mindset mediates how effort is seen. How the students viewed effort provided insights into their implicit beliefs of intelligence. Analysis of interview data revealed that students had very different understandings of the word ‘effort’ and what it meant
in relation to their school work. Again, students provided more than one definition of effort resulting in the percentages greater than 100%. The three most popular definitions of effort were i) trying hard or working hard (62%); ii) doing your best (36%); and iii) putting in time and persevering with a task (11%). Three students were unable to explain the meaning of effort.

Interview data analysis revealed that students viewed effort as vital to performing well at school. Twenty two (49%) students stressed how important effort was in relation to academic achievement. It had a “huge role”. Examples of their responses were as follows:

I think it’s definitely a big role, having to put in effort or choosing not to. (Patricia9)

Plays a good part of it. It’s an important part of it because if you don’t have effort then you won’t actually try for it, and if you don’t try then you just won’t get as good grades as what you would if you did try. (Lavinia8)

The students were results focused. They related effort to academic achievement and future goals and careers. However, two different views about the role of effort in achievement emerged from the data. These views included i) that having lower levels of intelligence required the need for greater effort, and ii) that effort was required to grow intelligence. A discussion of these two themes follow.

**Less intelligence, more effort.**

For some students, an individual’s level of intelligence determined the amount of effort that needed to be applied to school work. Students remarked that the more intelligent a person, the less effort was needed to academically achieve. Furthermore, the students indicated that they would have to work harder only if they were not intelligent or smart. Effort was polarised with intelligence in an inverse relationship. Rebecca’s comments illustrated this relationship as follows:

Intelligence kind of plays a role in how much effort you need to put in to achieve a goal. Because if you grasp a concept really well and you’re doing an assignment about that
concept you can do it easier, you don’t have to put as much effort in to do it, then maybe people who don’t grasp the concept that well. (Rebecca8)

Monica9 expressed the notion that “if students did not have natural ability then they needed to work harder”. Her comment has implications for a fixed mindset. For Monica having to work hard may imply that she does not have intelligence. When she encounters difficulty rather than trying new strategies or seeking feedback and staying on course, Monica, may not complete a task, as she holds the belief that her intelligence or ability cannot be changed or developed.

Helen commented that being smart required less effort.

But people who are smart, they know off the top of their hat, so they don’t actually have to work hard sometimes. (Helen8)

Bridget did not think of herself as being smart and so to compensate she could work hard:

I’m not smart, I’m always as smart as I would like to be, in some subjects, so probably hardworking. (Bridget8)

**Effort required to grow intelligence.**

The contrasting view expressed by students was that working harder made them smarter. Students believed that intelligence can be increased by one’s efforts. This view is indicative of a growth mindset. Carmen’s comments highlight this view:

I think they have a chance of becoming more intelligent because obviously you’re retaining more information and you learn more as you go, and it’s a cumulative process so if you’re learning more as you go it’s building on what you’ve already got. (Carmen11)

The following section provides evidence to answer Research Question Two: “What is the relationship between these beliefs and students’ self-reported learning behaviours?”
Work Ethic Scale

Nine questionnaire items formed the work ethic scale. The summary statistics appear in Table 4.2.

Table 4.2: Summary statistics for work ethic

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work ethic</td>
<td>483</td>
<td>23.00</td>
<td>13.00</td>
<td>36.00</td>
<td>25.23</td>
<td>3.93</td>
<td>15.45</td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td>483</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of the analysis of the data items relating to work ethic indicated a range of scores. Three students (0.6%) scored the maximum score of 36, while no students scored the minimum 9. One student had the lowest score of 13 (0.2%). Twenty five students (5.2%) scored 18 or below, indicating a weaker work ethic. In comparison, 34.9 per cent of students scored 27 or above, indicating a strong work ethic.

Pearson’s correlation coefficient was calculated to describe the strength and direction of the linear relationship between general growth mindset and the work ethic scale. Table 4.3 represents the correlation between general growth mindset and the work ethic scales.

Table 4.3: Correlation of growth mindset with work ethic scale

<table>
<thead>
<tr>
<th></th>
<th>Growth mindset</th>
<th>Work ethic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth mindset</td>
<td>Pearson’s Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>482</td>
</tr>
<tr>
<td>Work ethic</td>
<td>Pearson’s Correlation</td>
<td>.52**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>477</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
As illustrated in Table 4.3 there was a large, positive significant relationship between students’ growth mindset and work ethic. The coefficient of determination was 0.27. General growth mindset helped to explain 27% of the variance in respondents’ scores on the work ethic scale. It is suggested that this outcome might be expected, given that a growth mindset is characterised by developing intelligence through effort.

The analysis of student responses to the questionnaire items for work ethic revealed a significant positive relationship between general growth mindset and work ethic.

Mueller and Dweck (1997) found that when asked to choose, students opt for different goals; half select performance (looking smart or ego involved) goals as their preferred goal and half select learning goals. Student responses to the questionnaire items for looking smart goals follow:

**Performance (looking smart or ego involved goals).**

Analysis of the questionnaire data revealed that the majority of students (75%) disagreed with the statement “it is important to me that I look smart compared to others in my class” and the majority of students (67%) also disagreed with the statement “I would rather be thought of as smart than hard working”. The emphasis for most students was not on looking smart compared to other students but on the value of being considered a ‘worker’. The Pearson correlation coefficient was calculated to describe the strength and direction of the linear relationship between general growth mindset and the looking smart scale. Table 4.4 represents the correlation between these two scales.

**Table 4.4: Correlation of growth mindset with looking smart (ego involved) scale**

<table>
<thead>
<tr>
<th></th>
<th>Looking smart</th>
<th>Growth mindset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looking smart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson’s Correlation</td>
<td>1</td>
<td>-.13**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.00</td>
</tr>
<tr>
<td>N</td>
<td>487</td>
<td>481</td>
</tr>
<tr>
<td>Growth mindset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson’s Correlation</td>
<td>-.13**</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>481</td>
<td>482</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
As illustrated in Table 4.4 there was a small, negative significant relationship between growth mindset and looking smart, \( r = -.13 \), \( n = 481 \). The coefficient of determination was .02 \((.13 \times .13)\). General growth mindset helped to explain only 1.8 per cent of the variance in students’ scores on the Looking Smart scale. It is suggested that this outcome might be expected, given that a growth mindset is less characterised by ego-involved goals (students wanting to compare favourably to others) and more characterised by learning or task goals. The relationship is however weaker than expected. It is suggested that this result may reflect students’ having both learning goals and looking smart goals - the desire to work hard and to be viewed by other students as being smart. Learning goals and looking smart goals may not be mutually exclusive as some students may hold mixed versions of both.

**Implicit Theories of Intelligence and Self-reported Learning Behaviours**

To enrich our understanding of work ethic and how this was related to growth mindset, qualitative data were gathered from the subset of students during interviews. Analysis of the interview data revealed that there was an extensive variety of self-reported tasks that constituted working hard at school. Twenty five students (56%) agreed that they work hard all the time and twenty students (44%) gave various reasons why they didn’t always work hard. The most common themes for hard working behaviours are recorded in Table 4.5 and presented in descending order of frequency as voiced in student interviews. In some instances, the students provided more than one example of learning behaviours, resulting in the total number of behaviours exceeding the total number of students in the sample.
Table 4.5: Learning behaviours

<table>
<thead>
<tr>
<th>Themes</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studying</td>
<td>13</td>
</tr>
<tr>
<td>Taking notes</td>
<td>13</td>
</tr>
<tr>
<td>Listening in class</td>
<td>11</td>
</tr>
<tr>
<td>Asking teacher for help/advice</td>
<td>9</td>
</tr>
<tr>
<td>Paying attention not getting distracted</td>
<td>9</td>
</tr>
<tr>
<td>Completing homework</td>
<td>9</td>
</tr>
<tr>
<td>Reading</td>
<td>6</td>
</tr>
<tr>
<td>Being organised and conscientious</td>
<td>4</td>
</tr>
<tr>
<td>Completing assignments</td>
<td>4</td>
</tr>
<tr>
<td>Going beyond what is asked</td>
<td>4</td>
</tr>
<tr>
<td>Participating in lesson</td>
<td>3</td>
</tr>
<tr>
<td>Completing practice tests</td>
<td>2</td>
</tr>
<tr>
<td>Not procrastinating</td>
<td>2</td>
</tr>
<tr>
<td>Having patience</td>
<td>2</td>
</tr>
<tr>
<td>Being positive</td>
<td>1</td>
</tr>
<tr>
<td>Attending school</td>
<td>1</td>
</tr>
</tbody>
</table>

Studying, was the most popular learning behaviour, and for most students meant the reading of their textbooks and notes and trying to understand and remember what they had been doing in class. Studying was equated with actually learning their subject material. Most students recognised the importance of working hard in order to improve school performance. However, for some students working hard did not equate to developing their intelligence.

There were three additional learning behaviour themes that arose from the interview data analysis:

- a moral view of effort;
- real “understanding”; and
- wasteful effort (long-term implications).
These themes will now be reported.

**Moral view of effort.**

The majority of the students indicated the connection between a sense of worth and being viewed as hard workers. There was a sense of honour in working hard; a moral standpoint irrespective of the outcome; such as ‘always do your best’.

Students perceived that the act of working hard was associated with gaining respect from their teachers and parents. Nerida highlighted this in her responses:

> I think people who work hard deserve to be admired. People who are smart, yes, they can do well, but people who start from the lower and work their way up, that’s something to be proud of. (Nerida11)

Because students ‘know or sense’ what parents and teachers expect of them, a student may appear to have a growth mindset when she praises the value of effort but this may be a camouflage for her fixed beliefs.

Students voiced the importance of being recognised as a person who applies effort, as Carmen explains:

> I think it’s just the perception of yourself, like as a person if other people see you as hardworking then they’re going to respect you and they’re going to see that you are committed to achieving. And if they see you as hard working then they will like, respect you and you can see yourself as a hardworking person and that can also motivate you to achieve even more. (Carmen11)

This sense of honour was also balanced with a sense of ‘work ethic justice’ in that people who worked hard deserved to do well, as expressed by Shiobhan:

> I think you’ve got to put in as much effort as you will take out of it, like, however much effort you put in, you will get back in satisfaction that you’ve done well in class or done well in the whole year at school. (Shiobhan10)
Many students advocated effort related achievement as being ‘more honest’, compared to achievement through “innate” ability which came naturally, as described by Elizabeth.

Because I’d rather people know that my achievements aren’t just because I lounge around and naturally do something. I would want people to think I’m a hard worker and if I want to do something, I’d go for it and try and achieve it. (Elizabeth10)

Being smart for some students was a “given”, which one had no control over, but there was a choice to work hard, as described by Rebecca.

Smart is just the things you can do, hardworking is it’s like even if you can’t do something you can learn how to do it. Like you could do it in the future. (Rebecca8)

Some students expressed that intelligence was viewed negatively by others. Julie was concerned with how being smart was viewed.

If I’m smart, that could definitely be connoted with I don’t try or that because I think I’m smart or because someone else thinks I’m smart, then I’m not going to put in any effort because I’ve already reached my full potential, which is definitely wrong. Whereas if I am portrayed as being hard working, that means I’m going places and I’m actually trying harder than what most would. (Julie11)

Being a hard worker was also viewed as having ‘out of school’ value. Students perceived that employers valued employees who worked hard and had potential and so it was an advantage to have a high work ethic particularly if noted in a school reference. Marilyn shared her views:

If you take an employer, and you have someone who has really good marks, but they don’t really try and if you have someone whose marks are OK but tries a lot then I’d probably pick the person who gives their all. (Marilyn10)

Real understanding.

The need to understand their work and not just to be “doing it” was an issue for students. In some cases the lack of understanding led to doubts about ability and whether the work was
“beyond them”. Several students commented that failure to understand the work resulted in a failure to apply effort, and resulted in consequential negative effects on grades. For example:

When I don’t understand it. If I don’t understand something I don’t try hard, because I think I’ll never understand it sort of. (Wendy11)

The need to understand class work gained an even greater emphasis when discussing mathematics. This will be reported and discussed in Chapters Six and Seven.

**Wasteful effort – trying without gain.**

Students’ comments highlighted that the study methods used and the quantity and type, of content to be studied, could result in changes to intelligence. Julie states:

If you’re putting in the effort, then you’re going to get somewhere. Because if you keep trying and you keep putting in that effort, then it may not be at the start but you will eventually get smarter. It’s definitely a progressive thing though; it’s not something that will happen straightaway. (Julie11)

Although students recognised the value of effort in academic achievement they had several reservations. One reservation was in relation to the notion of studying irrelevant concepts that resulted in wasting time. Study needed to be effective in order to apply the information learnt. Cassandra states:

Heaps of study may not help if you just don’t get what you are doing. (Cassandra11)

Working hard was not just doing ‘busy work”. Students argued that there was the need to comprehend the content of study in order to become smarter. Elizabeth10, pointed out that it was “not about working harder but about working smarter”. Students also queried whether just knowing more made you smarter. Kay posed the question:

I don’t think you can get smarter, you can just learn a lot more. Am I smarter now in Year 11 because I know more than what I knew in Year 7? (Kay11)
Students may believe that effort was necessary for a specific purpose and so worked hard to improve short term performance. Students may have doubts about their long term improvements in the subject depending on how much effort was required and how successful the effort was in producing the desired results. Students described their own and others’ experiences of working hard and failing to improve their results:

Like you’ve got some students that work really hard and may only achieve at an average level then there are those students who don’t work very hard at all and they still achieve really well. (Sandra11)

I think in the majority of cases effort works, but in a few cases, there are people who try really hard and they can’t get those marks. (Cassandra11)

Unless effective strategies are utilised to ensure that effort is productive and worthwhile students came to view their effort as a waste of time and questioned their intelligence. Rather than a positive relationship between effort and intelligence, their lack of success despite their effort was viewed as compensatory for their lack of intelligence.

Students worked harder in some subjects than others, and their decision regarding the amount of effort required was based on several reasons. These reasons included subject demands set by either the teacher or as a result of the nature of the subject, whether the subject was compulsory or an elective, and whether students enjoyed the subject. Marilyn shared her thoughts:

Well it depends maybe on what subject. Like there are some subjects which you have to work hard if you want to succeed. But then, the other ones, it doesn’t take as much effort to get the good grades. (Marilyn10)

Self-defeating prophecies caused by disinterest in a subject may lead to ‘innate’ beliefs as expressed by Barbara:

If it’s a subject I don’t like I almost put myself down and say that I’m not very good at it, I ‘m not going to get a good mark anyway. So I don’t exactly try which isn’t the right thing. (Barbara10)
Whether it is a lack of understanding and the questioning of the appropriate effort or the halt of effort after unsuccessful outcomes, both have consequences for mindset. Effort viewed as “wasteful” by students has the potential to result in a fixed mindset. The discussion of these findings is addressed in Chapter Five.
Chapter Five: Discussion

Implicit Theories of Intelligence (Mindset)

Chapter Five is the first of three discussion chapters, and addresses the findings associated with research questions one and two. What implicit theories of intelligence or mindset do female secondary students hold? In particular, what beliefs do they hold about ability and effort and their roles in academic achievement? What is the relationship between these beliefs and students’ self-reported learning behaviours?

Quantitative analysis of the school sample mindset data revealed that over 66% of students were in agreement with the general growth mindset statements; supporting the statements that their intelligence could be developed or grown. The student interviews however revealed a far more complex, and at times contradictory picture. The majority of students’ responses revealed elements of both growth and fixed implicit beliefs of intelligence. Only a minority of students had unequivocally either a growth or fixed mindset.

While, Dweck (2006) distinguished two mindsets, fixed and growth, the interview data analysis revealed that there was great variation in growth and fixed mindset beliefs - it was not a simplistic divide. Interestingly, Dweck’s theory has been criticised for not considering that individuals simultaneously hold both beliefs concurrently (Schunk, 1995). Furthermore, Kristjansson (2008) also argued that Dweck’s work was too decisive, forcing individuals to fall within the strict dichotomies of either having a growth or fixed mindset. Dweck (2006) has acknowledged that many people have elements of both fixed and growth mindset and mentions “I’m talking about it as a simple either – or, for the sake of simplicity” (p. 47).

Data analysis revealed that students had difficulty defining the term intelligence. The term intelligence did not have a uniform meaning for the students. The word intelligence is not used as frequently today as it was in the 1950s and 60s when Intelligence Quotient (IQ) testing was prevalent in schools and people were exposed to the term. Li and Lee (2004) agree that intelligence is a very nebulous term. In the 21st century, in non-academic vocabulary, the word
has generally been replaced with other words for example, smart, clever, brainy and ‘being a nerd’. The term intelligence was possibly not fully understood by all students who completed the questionnaire. Interviewed students were able to explain and discuss their understanding of the term and gave added value to its meaning. The findings illustrate that students have varying personal definitions of intelligence and as Lüftenegger and Chen (2017) point out, most people have a “multidimensional view of the construct” (p. 103).

Perhaps students’ lack of understanding of the term intelligence may have led them to separate school performance from intelligence as they may not have related intelligence to brain function or understood that the brain can develop its capacity for learning. Students may also not have been explicitly taught ‘brain biology’ or have learnt about brain plasticity. Although the interviewed students generally believed that school performance was malleable and not fixed, a possible concern if students do not link effort to developing their intelligence is that they may not consider themselves ‘bright’ enough to study more challenging courses. These students may consequently cap their developing academic potential early in their careers particularly if their hard work is not producing quality results.

Interview data analysis revealed there was no over-arching growth mindset belief for all the students who could be considered to have this mindset. While some students believed in total development of intelligence by effort with no innate beliefs, the variation in growth mindset beliefs held by other students was derived from the importance they gave to innate intelligence and to its development by effort. Dweck (2006) did not distinguish between the belief that intelligence is fully developed by effort (no recognition of innate talents) and the belief that intelligence is initially innate which then develops. Both are implicit beliefs about the malleability of intelligence but have different emphases. The latter belief that intelligence is initially innate, may not be limiting if the student believes that people all commence life at different points and development can occur. Whether the belief would become more fixed in time would depend on the whole set of beliefs that a student had in regards to their potential for intelligence growth.
Variation in Mindset Beliefs

Inheriting intelligence.

Interview data analysis also revealed that students’ mindsets were overlaid by three other variations in student beliefs. Firstly, the very popular belief that intelligence was inherited (innate) and could be further developed by learning and life experiences, had the potential for significant learning consequences. The consequences of this belief included questioning how much natural ability or intelligence was possessed and how much development from the ‘baseline’ was possible. How much a student believes in natural ability or intelligence, and how much importance is placed on effort to develop this intelligence, would be critical to students’ mindsets. It would be expected that a student who placed a 30% weighting on innate intelligence and 70% on effort to develop this intelligence would have a different mindset than a student who placed 70% weighting on innate intelligence and only 30% on effort. Dweck (2000) pointed out that students with a growth mindset will place a great deal more emphasis on effort, while those with a fixed mindset will emphasise innate intelligence. Interview data analysis, however, did not support Dweck’s distinction as 95% of interviewed students with variations in intelligence mindsets placed more emphasis on effort than intelligence in school achievement. Again, it may be further evidence that students have a strong belief that effort improves their competencies, particularly knowledge and skills – “the belief that one must try one’s hardest in all things to get a better outcome” (Stables et al., 2014, p. 10), but don’t relate effort with developing their intelligence. For some students, their beliefs about whether they could develop their intelligence seemed to be a separate construct. Students may have also learnt that effort pleases their parents and teachers and a ‘good student’ works hard irrespective of their beliefs about intelligence.

Capping intelligence.

Secondly, the students who set a ceiling or cap on their intelligence, by assuming they could only improve to a certain level, showed evidence of holding both a fixed and a growth mindset (Schunk, 1995). A student might believe there is an upper limit to ability that cannot be exceeded through effort, persistence or use of effective task strategies (reflecting a fixed mindset) or the
student might believe that this limit on ability is high and working hard (exerting effort) may help to improve one’s ability up to that level (reflecting more a growth mindset). The capping of intelligence may be academically harmful to the student, and teachers need to be aware of this belief. The belief is self-limiting and interview data analysis reveals that the belief is commonly held by students in the sample. Whether this belief is more popular in an all girls’ school is open to question, and further research.

Multiple intelligences.

Thirdly, the term multiple intelligences was raised in the student interviews. Dweck’s (2006) theory of implicit intelligence does not distinguish between particular intelligence types. Data analysis revealed that some students believed that separate dimensions of their intelligence were fixed while other dimensions were malleable. Students may identify themselves as having visual or kinesthetic abilities, for example, and prefer to learn using these abilities. Students may prefer certain learning activities or learning styles, however this may lead to a narrowing of learning opportunities. Unfortunately, students may self-identify with these learner categories and abandon tasks quickly or not attempt a task that is offered using their non-dominant learning style. For these students, their understandings of intelligence may have implications for a fixed mindset, as they may not think they have the type of intelligence required to complete a task, and so do not attempt it, or fail to persist with the task. This mindset may have repercussions for the broad range of subjects offered in high school, as students reject or accept subjects in terms of where they ‘see’ their strengths/types of intelligence. Professor Stephen Dinham in an interview with Independent Education (Osborne, 2017), states that categorising students as having particular learning styles suited to their intelligence may “constrain the way they develop, the tasks they take on and the idea of themselves as learners” (p. 2). Professor Dinham further states that reliance on learning styles for teaching encourages a fixed mindset in students.
The Concept of Effort

Students’ interview comments also revealed their different understandings of the concept of effort and its application to their school work. Students frequently provided several meanings of effort and three students could not define the term. Stables et al. (2014) state that “the literature on effort is thin given the ubiquity of effort as an educational construct” (p. 5). The word effort is frequently used by teachers, however, the meaning may be unclear to students. Teachers frequently encourage students to apply themselves and put in more effort. Understandings of effort are not uniform and Stables et al. (2014) argue that where effort has been a focus of research, “it has been taken as an un-problematised factor rather than a contested concept” (p. 3). The findings of Chapter Four suggest that student beliefs about effort are very diverse. Therefore, there may not be a shared understanding of effort between the teacher and students or even between students. It is suggested that it would be better for teachers to explicitly explain or model the type of effort required for a task.

Relationship between effort and intelligence.

There were two major ways students viewed effort and its relationship with intelligence. Firstly, effort was positively related to intelligence, in that hard work could result in students’ intelligence being developed. This view was expressed by the majority of students. Despite the failure to directly refer to the term or notion of intelligence, students’ responses indicated that increased effort impacted on their potential to achieve better results and academic outcomes. Secondly, effort was inversely related to intelligence such that students with low ability or intelligence must work harder than students with high intelligence, thus reflecting a more fixed mindset. In this situation effort may be viewed as the ‘poor cousin’ to intelligence. Interview data analysis revealed many different definitions of intelligence. Muenks and Miele (2017) point out that the way students think about effort and ability may vary on how they currently conceptualise ability or intelligence itself. If they perceive intelligence as underlying capacities, then students may think in terms of the inverse relation between effort and ability, but if they perceive intelligence as a set of skills or competencies, then they may be more likely to regard effort as being positively related to intelligence. How students define intelligence is very important in understanding
mindset. Defining intelligence as capacity hints at innateness and not having the ability to be changed, whereas defining intelligence as competencies, implies development and improvement through effort.

The students who believed that intelligence was innate raised the concepts of control and choice as issues linking to, or influencing intelligence and effort. They proposed that working hard was a choice over which there was control, however, being smart was associated with innate ability over which you had no control. The consequences of this belief is indicative of the fixed mindset.

Another factor to consider is how situational cues in a context influenced how students viewed the relation between effort and ability (Muenks & Miele, 2017). Interview data analysis revealed the different emphases students gave to the role of effort, ability and achievement. If the emphasis in the classroom was on competition for academic places, with its inevitable student comparisons and ego-involving situations, then these cues may elicit an inverse relation between effort and ability. In contrast, a classroom where task mastery was encouraged and celebrated then these cues may elicit a positive relation between effort and ability. Dweck (2010) recommends the use of the word “yet” whenever students say they can’t do something or are not good at something. Using ‘yet’ “conveys the idea that ability and motivation are fluid” (p. 18).

Depending on the subject teacher’s skills in developing the classroom context for learning, students could view the relation of effort and ability as either positive or inverse and thus the student’s mindset will become domain specific.

The literature on implicit beliefs of intelligence, reveals that student’s growth in school achievement is sometimes not differentiated from growth in intelligence. Hochanadel and Finamore (2015) highlight that “students who value effort are said to have a growth mindset” (p. 48). Interview data analysis indicated that this was not necessarily correct. Students may indeed value effort when rewarded with improvements in school achievement, however, these same students may not all believe that their intelligence has changed or that it can develop. Dweck (2000) states that in an incremental or growth theory of intelligence, “intelligence is a dynamic quality that can be increased through your efforts” (p. 20). These implicit beliefs are about the brain – whether people see their intelligence as something that’s stable or something that can
grow and change. Students may not believe they can become more intelligent, however, they may believe, to a certain point, that applying effort results in good school grades. This is an important differentiation. Data analysis showed that some students do not necessarily link brain development or intelligence malleability to achieving well at school unless they have been explicitly taught these concepts. The analysis also revealed that some students described a knowledge component in their definition of intelligence regardless of their mindset and this might partly explain the large emphasis placed on effort. Cain and Dweck (1989) had proposed that individuals may include both a stable capacity and an acquirable knowledge component in their definition of intelligence and entity theorists (fixed mindset) may focus more attention or weight more highly, the capacity than the knowledge component. The reverse would be true for incremental theorists (growth mindset).

The work ethic findings reported in Chapter Four indicate that 35% of students in the school sample had a strong work ethic, a reflection of students’ general growth mindset, in that working hard or applying effort was recognised as crucial in improving school results. Female students have been reported to value effort more than males (Francis et al., 2014; McCrea et al., 2008) and have more effortful study strategies, report studying harder, and are more likely to adopt effortful learning goals than male students. (Ablard & Lipschultz, 1998; Howe & Berenson, 2003; Yeung, 2011). In an all-girls school there may be a multiplier effect of even greater promotion of effort and this is evidenced in the self-reported learning behaviours expressed by individual students. The interviews revealed that most of the students had a work ethic, however, this did not necessarily indicate or guarantee a growth mindset for intelligence.

Whilst the findings of this study indicate that students define the concept of effort quite differently, it was overtly clear that the students were able to identify a diversity of learning strategies that illustrated ways to demonstrate their effort. The students recognised that the application of effort, and the strategies employed to demonstrate effort, were clearly related to improvements in academic achievement. Tempelaar et al. (2015) assert that the crucial driver of effort is students’ self-perceptions of the role effort plays in learning. Conversely, a few students questioned the direct relationship between the application of effort and academic achievement.
In regard to mindset, this had implications for students continuing to apply effort, when the expected outcomes were not achieved or produced.

Data analysis indicated that students valued the need for effort and generally did not consider it ‘uncool’ to work hard. The valuing of effort was directly related to improving school achievement. The findings also showed evidence that some students failed to believe that they could develop their intelligence. If the students’ perception of their own ability are low or poor then they may perceive that there would be no subsequent need for effort. It can become a negative self-defeating view that further convinces the student of their limited ability. The questioning of the appropriate effort, or the cessation of effort after unsuccessful effort, is more likely for students with a fixed mindset. Alternatively, effort may only be applied in the short term for specific tasks or specific purposes when the student believes she has the capability for the task, however for long term success in the subject, this may not be the case. The student may believe that she has limited ability, and thus is unable to improve enough to master a subject, resulting in the action of subject avoidance. Effort viewed as being ‘wasteful’ also has the potential to result in a fixed mindset as students potentially doubt their ability to improve if resulting achievement is low due to ineffective effort. The role of the teacher is crucial in this process, ensuring that student effort is productive, and leads to improved learning, and learner realisation that their ability in the subject is developing.

The work ethic scale in the questionnaire, indicated that students were more concerned with learning goals than performance goals, as validated by the general growth mindset scale, looking smart scale and supported by interview data analysis. However, students with a high work ethic also spoke about performance approach goals but not performance avoidance goals. Although the students emphasised learning goals, an emphasis was placed on performance approach goals such as earning academic awards, competing with peers for places in class, and earning the respect of teachers, parents and peers. Midgley et al. (2001) point to the facilitative nature of performance approach goals when combined with mastery goals. The findings are supported by the work of Chen and Wong (2014), who demonstrated a positive association between performance approach goals and academic achievement in the Chinese cultural context.
Interview responses indicated that performance approach goals were also important to students in this Australian school and were combined with their learning goals to achieve quality academic outcomes.

**Mastery and performance.**

The findings from Chapter Four revealed a tension for students in having both mastery and performance goals, such that many students were aiming to increase their competencies but were also wanting to gain positive judgments of their competencies. Dinger and Dickhäuser (2013) reported that students subjected to the growth mindset condition held “higher levels of mastery goals and lower levels of performance-avoidance goals than students in the fixed condition” (p. 46). Grant and Dweck (2003) agree that “performance goals that are focused on validating ability can have beneficial effects on performance when the student is having success but these same goals can predict impaired motivation and performance after setbacks” (p. 552).

Dweck (2000) reminds us that “an overemphasis on performance goals can foster a helpless response” (p. 16). Therefore, the students who are valuing teacher, peer and parent approval for high performance may be at risk when they do not achieve their expected results. There would also be concern if proving ability became so important to students that it drove out mastery goals.

Midgley et al. (2001) point out that the “emphasis on performance goals increases and the emphasis on mastery goals decreases as students move up in grade level” (p. 83). It was apparent in the course of student interviews, particularly amongst the years 10 and 11 students, that this tension existed. Students speculated on easier success and higher achievement in less demanding courses compared to the struggle to master more challenging courses. Undoubtedly, the tension between performance and mastery goals has implications for the study of mathematics at the more advanced level.

**Real understanding.**

Interview data analysis also pointed to student emphasis given to the importance of “really understanding” subject content in class. Repeated lack of understanding in a subject has implications for student mindset. Students may doubt that they have enough ability to
understand or that they can develop their ability sufficiently to understand. Both conditions have ramifications for the study of mathematics, in particular.

**Moral value of effort.**

Another aspect that emerged from the interviews was the moral aspect of assuming a good work ethic. The moral aspect was reflected in the students’ desire to earn the respect of teachers and other students by adopting a strong work ethic. The students voiced their appreciation of a work ethic that developed one’s own self-worth and acquired the respect of others. There was a certain honesty or sense of justice in this positive work ethic, in that the students viewed a relationship between trying hard and deserving to do well. Scott and Marshall (2014) argue that the idea of productive labour, or work, being valued in and for itself by those who do it is a unique product of Western European culture and derived from the Protestant work ethic; such that work is presented as a religious and moral obligation. The work ethic construct has been defined “as a multidimensional set of values reflecting the importance of work in an individual’s life” (Meriac, Slifka, & LaBat, 2015, p. 401). Miller, Woehr and Hudspeth (2002) found that work ethic was positively correlated with conscientiousness. Student interview responses revealed an association between having a moral view of effort and being conscientious.

Students perceived that the demonstration of effort was to be applauded as it was seen as the necessary pathway to improved learning, higher grades and better career prospects. Because students ‘know or sense’ what parents and teachers expect of them, their emphasis will be on effort. Students indicated that they valued effort up to a point, as long as it brought about the expected academic results. When a student is academically successful their implicit beliefs about intelligence are not called into question, however the ‘true’ mindset may not become apparent until the student experiences disappointing results or failure on a task.

Traditionally, in our western culture, natural talent has been lauded over effort and generally talents or abilities were seen as fixed at birth and unchangeable. The implications of these beliefs for teachers is that growth mindset education may refute the misconception of fixed innate abilities over which we have no control and must accept as a given. The ramifications for teaching
and learning are immense, as teachers may not be initially aware that a student has a fixed or a growth mindset in a particular domain. Students may work hard and appear to have a growth mindset but under repeated challenging conditions, this mindset may be threatened, particularly if they do not have effective strategies to learn. Over-concern with ability and worrying about its adequacy leaves students vulnerable. The students who have unhelpful beliefs about their abilities may build psychological barriers which will prevent them from being able to seize opportunities for growth in the classroom.

What students believe about intelligence, effort and their own potential to learn in school, affects their level of investment in the educational process. Carpenter and Pease (2013) mention an aphorism that underscores the importance of a learner’s mindset regarding a particular task. Henry Ford reportedly said, “whether you think you can, or you think you can’t, you’re right” (p. 46).

Schools can send out conflicting messages to students. Intelligence may be conflated with school performance and not effort; and school work or the big picture of learning is not explicitly explained as developing the brain and the intellect. Intelligence mindsets, their causes and effects extend beyond the confines of the classroom and this will be reported and discussed in Chapters Eight and Nine respectively. Chapter Six will now report the questionnaire and student interview data analysis concerning mindset and mathematics.
Chapter Six: Results
Mindset and Mathematics

Introduction

Chapter Six is the second of the three results chapters and presents the findings related to the following research questions:

3: What implicit theories of intelligence specifically related to mathematics are held by a sample of female secondary school students?

4: What is the relationship between these beliefs and the participation of a sample of female secondary school students in mathematics?

The research questions act as organisers for the presentation of the results from the data analysis. The data for this chapter were derived from an analysis of two sources:

i) students’ responses to the Mathematics and Mindset Questionnaire; and

ii) face to face interviews with a subset of 45 students from the sample population.

As described in Chapter Three, 487 female students from the selected secondary school in the NSW Central West, completed the “Mathematics and Mindset” questionnaire. The findings from the questionnaire assisted in identifying students’ mindset to mathematics by examining scales of:

- mathematics growth mindset; and
- English growth mindset (as a comparison).

The findings from the questionnaire and interviews provided evidence for:

- implicit theories of intelligence related to mathematics and the role of effort;
- mathematics mindsets and mathematics participation (selection) in Years 11 and 12;
- mathematics course preferences and selection;
- mathematics mindsets and mathematics participation (engagement) in Years 11 and 12;
The findings from the interview provided evidence for:

The profile of students:

- who did not select a mathematics course to study for Years 11 and 12; and
- who selected a high-level mathematics course to study for Years 11 and 12.

The findings from each of the questionnaire mindset scales follow:

**Mathematics Growth Mindset**

Seven questionnaire items formed the Mathematics Growth Mindset scale. The summary statistics appear in Table 6.1.

<table>
<thead>
<tr>
<th>Number of students</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>477</td>
<td>20.73</td>
<td>21.00</td>
<td>21.00</td>
<td>3.79</td>
<td>21.00</td>
<td>7.00</td>
<td>28.00</td>
</tr>
</tbody>
</table>

There was considerable variation in the sample in relation to mathematics growth mindset. Nine students (1.9%) scored the maximum of 28 and one student (0.21%) obtained the minimum score of seven. Seven per cent of students had a score of 14 or below, indicating a fixed mindset. In comparison, 58% of students had a score of 21 indicating agreement with mathematics growth oriented statements.

These findings then lead to the comparison between students’ mathematics growth mindset and their beliefs in relation to another subject, in this case English. English was selected as a comparative, as it is a mandatory subject prescribed by the NSW Education Standards Authority, to be studied by all students.

**English Growth Mindset**

In order to investigate whether there was a significant difference in students’ implicit beliefs about intelligence between mathematics and other subjects, a comparison was made with the subject English. Seven questionnaire items constituted the English growth mindset scale. The summary statistics appear in Table 6.2.
### Table 6.2: Summary statistics for English growth mindset

<table>
<thead>
<tr>
<th>Number of students</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>481</td>
<td>21.21</td>
<td>21.00</td>
<td>21.00</td>
<td>3.50</td>
<td>20.00</td>
<td>8.00</td>
<td>28.00</td>
</tr>
</tbody>
</table>

There was a range of English mindset scores indicated by students in the sample, with 12 students (2.5%) achieving the maximum score of 28 and one student (0.2%) obtaining the minimum score of eight. A fixed English growth mindset was indicated by four per cent of students scoring 14 or below. In comparison, 63% of students scored 21 or above, indicating agreement with the English growth oriented statements.

Four questions formed the general growth mindset scale and seven questions each formed the English and mathematics scales. In order to compare the scales of mathematics growth mindset, English growth mindset and general growth mindset, the average was calculated and the means and standard deviations are presented in Table 6.3.

### Table 6.3: Descriptive statistics for mindset scales

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average growth mindset</td>
<td>482</td>
<td>1.00</td>
<td>4.00</td>
<td>3.01</td>
<td>.51</td>
</tr>
<tr>
<td>Average English mindset</td>
<td>481</td>
<td>1.14</td>
<td>4.00</td>
<td>3.03</td>
<td>.50</td>
</tr>
<tr>
<td>Average mathematics mindset</td>
<td>477</td>
<td>1.00</td>
<td>4.00</td>
<td>2.96</td>
<td>.54</td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td>469</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A one-way repeated measures ANOVA was conducted to compare scores on mindset for general growth, mathematics and English. There were some significant effects for mindset, Wilks’ Lambda = .97, $F = (2, 467) = 5.97$, with a probability value of .00 and the multivariate partial eta squared = .02 which indicated a small effect size. The pairwise comparison of mindset scales appear in Table 6.4.

### Table 6.4: Pairwise comparisons of the mindset scales
<table>
<thead>
<tr>
<th>(I) Mindsets</th>
<th>(J) Mindsets</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig. b</th>
<th>95% Confidence Interval for Difference b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>1 General</td>
<td>2</td>
<td>.05*</td>
<td>.02</td>
<td>.02</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.01</td>
<td>.02</td>
<td>1.00</td>
<td>-.05</td>
</tr>
<tr>
<td>2 Mathematics</td>
<td>1</td>
<td>-.05*</td>
<td>.02</td>
<td>.02</td>
<td>-.09</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.06*</td>
<td>.02</td>
<td>.00</td>
<td>-.11</td>
</tr>
<tr>
<td>3 English</td>
<td>1</td>
<td>.01</td>
<td>.02</td>
<td>1.00</td>
<td>-.03</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.06*</td>
<td>.02</td>
<td>.00</td>
<td>.02</td>
</tr>
</tbody>
</table>

* Based on estimated marginal means
* The mean difference is significant at the .05 level.

The mathematics growth mindset mean was significantly lower than general growth and English growth mindset means. There was no significant difference between general growth and English mindset scales. This is a key result that has implications for students’ future participation in mathematics as the results imply that students have more of a fixed mindset for mathematics.

**Implicit Theories of Intelligence Related to Mathematics**

As the quantitative data analysis suggested, individual students differed in their implicit beliefs about intelligence in relation to mathematics. Interviews were therefore undertaken to seek a more nuanced understanding of the differences in mindset and how these differences impacted on students’ participation in mathematics.

As described in Chapter Three, 45 female secondary school students from the research site participated in face to face interviews with the researcher. The aims of the interviews were firstly, to add a description and depth to the concept of a moderately growth-oriented mindset for mathematics – ‘what does it look like’. Secondly to investigate the rationale for differences between the mindset scales. Thirdly, to explore the relationship between mindset and participation in mathematics. It was noted that the simplicity of the quantitative data belied the complexity of the qualitative data gained from the interviews.
Findings from the analysis of interview data are presented as two themes which assist in explaining and presenting examples of the results from the school population sample. These themes are i) implicit beliefs about intelligence or ability in mathematics, and ii) the role of effort. These two main themes will now be presented.

**Beliefs about intelligence or ability specifically related to mathematics.**

Three main beliefs arose from the data analysis. These beliefs included that:

- we are born with ability which can be developed;
- ability is developed over time (no recognition of innate ability) and;
- we are born with ability which cannot be developed, i.e. it is stable overtime.

Student concerns about their ability in mathematics were raised during the interview. Nearly half of the students (49%) argued that you can be born with ability but you also develop this ability or capability throughout your life. The remaining 22 students (49%) argued that your ability to undertake mathematics was developed throughout your life, with no mention of innate ability. The students likened their belief to being born as a blank slate – *tabula rasa* with their mathematical abilities being developed overtime. Only one student explicitly expressed the belief that ability in mathematics was innate and unchangeable: you have a “Maths kind of brain".

Margaret did agree however that working hard could improve her grades. She related effort to improving her mathematics results but not to developing her mathematical intelligence. The student’s comment illustrated a fixed mindset response for mathematical intelligence. She shared her belief as follows:

> I think you’re born with it. I think so, like my Mum was terrible at Maths too, like so I don’t know, I feel as though it is. Yeah, you’ve either got like a Math kind of brain or like an English and History kind of wordy, reading kind of brain. (Margaret10)

These beliefs will now be further discussed.

**Born with mathematical ability which can be developed (innate + developed belief).**

There were many variations in students’ implicit beliefs about growth in mathematics ability. As illustrated by comments expressed in students’ interviews, there was a general recognition that
everyone has different abilities in mathematics. In addition, students recognised that ability could be altered. The following excerpts from student interviews illustrate these beliefs:

I think it’s something you’re kind of born with but that can be developed, because my Dad he’s a really good mathematician; he’s an electrical engineer and he’s really good at Maths and I think I got that kind of aptitude from him. But I have the underlying basis of a good mathematician, I’m the one that’s built on the base to become who I am now. (Susan11)

I do think people have different abilities. I think everyone can develop it over time. It’s just about how much work they put in, and effort, and if they like it or not and the perseverance. (Deborah11)

The capabilities identified by the students included the ability to be logical, to see patterns, to solve problems quickly, to understand and comprehend with ease and to realise their capacity to improve in mathematics. As evidenced by the following quotes the students’ illustrated these capabilities:

It’s just like a click, it just makes sense in someone’s head. Yeah, and then with that sort of notion, they’re able to continue their growth of that knowledge. The logic. Like it is logical so it’s not all over the place. You can follow it in steps and that is helpful. (Alice11)

I just tend to understand it a lot quicker. I can sort of easily see patterns in Maths and how things link together. (Morwenna11)

Three students also assigned a limit to the amount of improvement that could be achieved. These students were fixing the level or degree of improvement. Students justified adopting this approach by saying:

But once again, there’s also that limit of where you just can’t. Like a person just can’t go any further. I think there is a limit to just how far you can go with that. (Eileen10)
I feel like it’s a certain degree where if you’re not going to get the concepts maybe you won’t get them, but that’s fine. (Alice11)

I think if you choose a level of Maths that you are capable of then you’ll go a lot better. (Kay11)

Kay did not place limits on her general intelligence but limited her mathematical intelligence. She was adamant that it would be better to select an easier mathematics course rather than a more challenging one in the senior years. Kay had already placed a ceiling on her mathematical ability. These beliefs may underpin the reasons why students do not select more challenging mathematics courses for Years 11 and 12. Doubts about the development of their mathematical ability may arise when students are confronted by the choice to engage in more demanding mathematics courses. These beliefs suggest a more fixed mathematics mindset.

**Ability is developed over time (no recognition of innate ability).**

Twenty two students (49%) acknowledged that mathematical ability could be developed over time, by learning and working hard (putting in effort) in mathematics. The students did not give credence to innate talent or natural ability for mathematics. These students argued that through hard work they could improve and excel. Working hard would help to achieve higher grades. There was a competitive edge to their successes as hard work resulted in high achievement. This was demonstrated by the following comments:

Mainly just because we’re all born equal with our brains still developing so I think it’s just like something you have to develop as you go on in the different subjects. (Kathleen9)

I think, if you start it at an early age then obviously it’s going to be easier once you get older but I think everybody develops a mathematics knowledge, like at different rates obviously but I think it’s definitely for everybody. Well I guess environment that you are growing up in. Like if you’re surrounded by a lot of Maths when you are growing up or in primary school or something then you’re going to learn more Maths than someone who isn’t exposed to that. (Carmen11)
The students expressed a variety of strategies to develop mathematical ability. The primary method was by applying increased effort. In applying effort to their mathematical study, the students gave recognition to supportive parents and effective teachers. Practical life experiences and availability of resources were acknowledged in assisting to develop mathematical knowledge, skills and confidence. The students recognised that enjoyment and interest were key to developing abilities as greater efforts would therefore ensue. This was illustrated by the following student comments:

I think it’s something you develop. Because like some people I guess have always been good at Maths, but they just must enjoy it a lot more, so therefore put in a lot more effort. But if you don’t enjoy it as much you don’t put in as much effort. (Kay11)

But everyone’s born the same way, they have no knowledge of really anything at all, and then as they get older, it just grows. And it depends what you find interesting, what you want to learn. (Anastasia8)

*Born with ability which cannot be developed (fixed).*

One student specifically mentioned her perception of the innateness of mathematical ability, that it was stable and fixed. Her opinion was that people either had this ability or they did not and Margaret hinted at a hereditary component that she must have “missed out on”. She believed that she could develop her general intelligence but doubted her mathematical intelligence which she claimed to be minimal and stable. Margaret expressed the idea that study could improve her mathematics grades as follows:

If you’re not that smart, if you put the effort in you can build your intelligence I guess. Some people are born like naturally smart at Maths, they just have a Maths brain, like I’m definitely not. I never really got Maths very well. I’ve struggled with it. I have to study for Maths, because otherwise I’d fail completely. (Margaret10)
Role of effort in mathematics.

As in Chapter Four, students’ related effort mainly to improving school performance. Forty students (89%), emphasised that working hard was the main way to improve their results in mathematics. There was no hesitation in their responses, and effort was emphatically endorsed. Generally when students spoke about the need for effort in mathematics it was related to achieving higher grades. During the interviews, there was no specific mention of effort developing their intelligence, however students expressed beliefs earlier in the interview about being able to develop their ability in mathematics by working hard. Their growth beliefs were implied rather than stated explicitly. This was demonstrated in Nancy’s response where she linked effort to growth in learning.

If you put the effort in to... if you’re not understanding something, and you think I’m going to get this by the time my next test comes up, and you study and study, and you do catch up, even find your own way to remember it, I feel that you are reaching your full potential in that area. (Nancy8)

With their strong belief in the need for effort, the students were able to expand on their perceptions of the concept of effort in mathematics. Students’ understandings of effort included tasks such as completing class work, completing worksheets, studying for tests and exams, doing homework and assignments, revising by taking notes, revising by doing practice questions from textbook, using online tutorials and practice tests, being attentive in class and listening, asking questions of the teacher and/or other students, being organised and prepared, reading ahead of the class, reading through concepts and applying them to different questions and memorising rules and tables. There was an extensive emphasis given to practice as a way of consolidating and remembering their mathematics. In some cases it took the form of a mantra, for example;

Like going home, reading through concepts again and then applying them to all different questions. And there’s practising, because practise can help make perfect. (Alice11)

For some other students the extensive practising in mathematics led to boredom and a lack of effort that may ultimately lead to lower achievement Wendy expressed:
For me in Maths, the easy part is understanding the concept. But the difficult part is continually doing it, because I understand it, I just never do the exercises or homework.

(Wendy11)

The majority of interviewed students also suggested that compared to other subjects, mathematics usually required the most effort. Year 11 students in particular, noted the impact of the mathematics 2 unit course.

I think because it’s so hard I have had to work so much harder and I think that has motivated me to do well and in doing that consciously I’ve just done well. (Carmen11)

I don’t find it difficult but you definitely have to put in the effort to do well. Just some of the concepts are challenging. Things that aren’t … cannot be related to in everyday life, like abstract concepts. (Julie11)

For some students mathematics testing gave rise to anxiety despite the amount of effort prior to examinations. Anastasia and Heidi spoke of being more anxious in mathematics than in other subjects.

I get how to do things, and my teacher describes it well, but then when I’m actually faced with it in a test, it’s just everything gets really jumbled, when I’m trying to work it out. It just, everything doesn’t make sense. (Anastasia8)

I understand the content in class, I can do homework efficiently and get everything done but as soon as I walk into an exam I can’t make the connection between the question and what I have to do. Maths is mainly exams. (Heidi11)

As in Chapter Four, two main beliefs of the role of effort in mathematics achievement emerged from the date analysis: i) effort was needed to develop mathematical ability, and ii) more effort was required if there was a lacking in mathematical ability. These two beliefs will be expanded.

**Effort was needed to develop mathematical ability.**

Natural ability was spoken of as a *bonus* but some students pointed out that working hard lead to higher achievement compared to students who were naturally good at mathematics and who
were not working hard. Marlene and Melanie’s comments highlighted the role of effort in mathematics. They stated:

> Because you know, if they have the natural ability and they don’t try, they might have that attitude, “I’m good at it naturally, so I don’t need to try hard”, then yeah, definitely if you work hard, then you can overcome the people who are naturally good at it. (Marlene8)

> Hard work and it all comes down to work ethic, and if they’re willing to improve. (Melanie11)

**More effort was required if there was a lacking in mathematical ability.**

Some students mentioned having natural ability or talent and being quite capable in mathematics. Natural ability was viewed as being advantageous for mathematics achievement. This belief was illustrated by the following student’s response:

> I think it depends on the person as well. Like if you’ve naturally got a mathematics mind then you’re going to find it easier than say other people who don’t, who have to work a bit harder to understand. I think to a certain extent, I think not as much as, I don’t know some people in my year for example, but I think I have got enough of a mathematics mind to be able to, if I work hard enough at it I can get it and understand it. (Carmen11)

For other students, like Barbara and Nerida the increased efforts due to lack of innate ability would be rewarded with high achievement.

> I think it depends on the person. Some people find it easy to do, like when they walk in they know what they’re doing and they can understand it after it’s been explained once, whereas other people have to work harder for it but they can still get as good a mark as the people who understand it straight off. (Barbara10)
So I knew a lot of people that are naturally smart at maths and they don’t need to study but I do know girls who were never really good at maths but are getting good results now because they studied hard. (Nerida11)

If a person lacked innate ability, Candice and Wendy pointed out that ability must then be developed.

Well you can be born with it or you can develop it over time, really, like you could hate Maths and then you could get into it and really enjoy it. Like, just having a knack with Maths. (Candice10)

You can be born good at Maths, but I feel that I wasn’t … and that I developed it. But then other people, from a young age, have just always understood Maths. In Year 7 I wasn’t very good at Maths at all, but then as I did more, and I found out that I liked Maths, I became better at it almost. (Wendy11)

The majority of interviewed students suggested that effort must be combined with ability to maximally achieve in mathematics. A key outcome arising from the data analysis was that effort was key to success in mathematics irrespective of ability beliefs.

A student in Year 11 who had been the dux of her year group, selected the highest course, mathematics extension 2 for the Higher School Certificate, humbly denying that she had mathematical abilities. Cassandra argued that her academic success was due only to hard work. She underestimated her academic potential in relation to her academic brothers.

I’m in a family of four kids and the three oldest ones have all done Extension 2 mathematics and that’s been like their best subject by far. But I’d say I’m a little different to them in my subjects. I think I’m the one that’s had to work harder for my Maths, whereas I look at them and I think that they, like I know for instance, one of my brothers didn’t have to study very much because he just got it, whereas I have to sort of put more of that effort in. (Cassandra11)
Cassandra did not seem to acknowledge her ability as she equated having to work hard with a lack of ability rather than effort developing her ability. This may also be an example of the *imposter phenomenon* in high achieving women (Clance & Imes, 1978).

The following section provides evidence for research question four, illustrating the relationship between implicit beliefs of intelligence in mathematics and the participation of a sample of female secondary school students in mathematics.

**Participation in NSW Mathematics Courses**

Participation in this context, is taken to mean *both* the selection of mathematics courses for Years 11 and 12 and students’ engagement in learning mathematics in senior classes. Mathematics is a compulsory subject from Years 7 to 10 in New South Wales, Australia and non-compulsory for Years 11 and 12. The most challenging course at the senior level is Extension 2 mathematics and the least demanding is General 1 (non ATAR course, not counted in the university admission rank). Participation in mathematics was assessed in the questionnaire by students’ intentions regarding senior mathematics study (for students in Years 7 to 10) and their mathematics subject selection in Years 11 and 12 (for students in Years 10, 11 and 12).

Student participation was also measured by student responses to three questions in the questionnaire: i) their enjoyment of mathematics (the nature and extent of students’ liking and enjoyment of mathematics), ii) their interest in mathematics and iii) their sense of belonging in the mathematics classroom. These questions constituted the mathematics engagement scale. This scale was also contrasted with the English engagement scale measured by student responses to three questions in the questionnaire: i) their enjoyment of English, ii) their interest in English and iii) their sense of belonging in the English classroom.

These data were further enriched by face to face interviews with 45 students ranging in age from 12 to 17 years. The interview data provided opportunities for more detailed and nuanced information on participation or non-participation in mathematics in the senior years. Information was sought to answer the key question of whether a student’s mathematics mindset was related to a student’s participation in senior mathematics. Data analysis from the questionnaire and
interviews relating to the number of students selecting a mathematics course in the Years 11 and 12 follow.

**Mathematics mindsets and participation (selection) in mathematics in Years 11 and 12.**

In the questionnaire, 77% of Years 7-12 students, responded that they *would be or have already* selected mathematics in Years 11 and 12. In comparison, 23% of students responded that they would not be selecting this subject or have not already selected mathematics in the senior years. The result that over a fifth of students did not wish to select a mathematics course in Years 11 and 12 may be reflected in the significantly lower growth mindset for mathematics as compared to general growth and English growth mindset.

In the interview, 38 students (84%) responded that they *would be or have already* selected mathematics in Years 11 and 12. The percentage of students in the interview was slightly higher than the school population sample for participation in mathematics in the senior years. This higher percentage might be expected as students who volunteered for the interview regarding mindset and mathematics may be more favourably inclined to study mathematics.

The findings from the questionnaire gave evidence in identifying the mindset of students who indicated selection of a mathematics course in Years 11 and 12 by examining:

- mathematics growth mindset and student participation; and
- general growth mindset and student participation.

The following statistical analyses are reported.

**Mathematics growth mindset and student participation.**

An independent samples t-test was conducted to investigate whether there was a statistically significant difference in the mean scores for mathematics growth mindset for students in the school sample who wished to select mathematics in Year 11 or 12 and for those students who did not. As the significance value for the Levene’s test is larger than .05 (.08 in this case), equal variances were assumed. The summary statistics appear in Tables 6.5 and the independent t-test results are recorded in Table 6.6.
Table 6.5: Group statistics

<table>
<thead>
<tr>
<th>Mindset</th>
<th>Do you think that you will choose Maths in Year 11 or 12?</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics growth mindset</td>
<td>Yes</td>
<td>362</td>
<td>21.28</td>
<td>3.51</td>
<td>.18</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>106</td>
<td>19.26</td>
<td>3.99</td>
<td>.39</td>
</tr>
</tbody>
</table>

Table 6.6: Independent samples test

<table>
<thead>
<tr>
<th>Total Maths growth mindset</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>3.01</td>
<td>0.83</td>
</tr>
</tbody>
</table>

The analysis of the independent t-test results indicated there was a significant difference in mathematics growth mindset scores between students who wished to select a mathematics course in Year 11 or 12 (M = 21.28, SD = 3.51) and those students who did not wish to take a mathematics course in Year 11 or 12 (M = 19.26, SD = 3.99; t (466) = 5.04, p = .00, two-tailed). The magnitude of the differences in the means (mean difference = 2.02, 95% CI: 1.23 to 2.80) was moderate (eta squared = .05).

Overall the students who selected a mathematics course in the senior years had a higher mathematics growth mindset than students who did not wish to take on further study in mathematics at the senior level. This is an important finding as students who have a growth mindset for mathematics might be more likely to participate in mathematics courses for Years 11 and 12. For schools in general the development of students’ mathematics growth mindset may be beneficial in increasing senior mathematics participation. These findings provide evidence indicating that beliefs about the nature of mathematical intelligence have a major impact on
participation in non-compulsory mathematics courses, particularly the positive role malleable intelligence beliefs play for mathematics students.

**General growth mindset and student participation.**

An independent samples t-test was undertaken to investigate whether there was a statistically significant difference in the mean scores for general growth mindset for students who wished to take mathematics in Year 11 or 12 and for those students who did not in the student sample. As the significance value for the Levene’s test is larger than .05 (.6 in this case), equal variances were assumed. The summary statistics appear in Table 6.7 and the paired t-test results appear in Table 6.8.

**Table 6.7: Group statistics**

<table>
<thead>
<tr>
<th>Mindset</th>
<th>Do you think that you will choose Maths in Year 11 or 12?</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>General growth mindset</td>
<td>Yes</td>
<td>364</td>
<td>12.21</td>
<td>1.99</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>109</td>
<td>11.70</td>
<td>2.15</td>
<td>.21</td>
</tr>
</tbody>
</table>

**Table 6.8: Independent samples test**

<table>
<thead>
<tr>
<th>General Growth mindset</th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>.28</td>
<td>.60</td>
</tr>
</tbody>
</table>

The analysis of the independent t-test results indicated there was a significant difference in general growth mindset scores for students who wished to take a mathematics course in Year 11 or 12 (M = 12.20, SD = 1.99) and those students who did not wish to take a mathematics course
in Year 11 or 12 (M = 11.70, SD = 2.15; t (471) = 2.29, p = .02, two-tailed). The magnitude of the differences in means (mean difference = .61, 95% CI: .07 to .94) was small (eta squared = .01).

A distinguishing feature of the students who had selected mathematics at the senior level was their higher general growth mindset compared to students who had not selected mathematics for their senior years. This result highlights the importance of even a general growth mindset for student participation in mathematics in Years 11 and 12.

For students at the end of Year 10 there are several mathematics courses available for study in Years 11 and 12. Student course selection appears as follows:

**Mathematics course preferences and selection for Years 11 and 12.**

The following section presents the mathematics course preferences for the:
- school sample; and
- subset of interviewed students.

Additional information was sought from the subset of interviewed students regarding their:
- reasons for selection of a mathematics course; and
- reasons for non-selection of a mathematics course.

Each of these will now be addressed.

**Mathematics course preferences – School sample.**

The following section outlines the analysis of questionnaire data for selection of a mathematics course for Years 11 and 12 by Years 10 to 12 students. These results appear in Table 6.9.

**Table 6.9: Years 10 to 12 mathematics course selection**

<table>
<thead>
<tr>
<th>Mathematics course</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics General</td>
<td>59.8</td>
</tr>
<tr>
<td>Mathematics 2 unit only</td>
<td>27.9</td>
</tr>
<tr>
<td>Mathematics Extension 1 (includes 2 unit Mathematics)</td>
<td>12.3</td>
</tr>
</tbody>
</table>
The most preferred course was general mathematics which is considered less challenging than the 2 unit mathematics course. The most challenging course, mathematics extension 1, was least preferred. 83.9% of Year 11 and 12 students were continuing to study mathematics for the H.S.C. The mathematics courses selected by Years 11 and 12 appear in Table 6.10.

Table 6.10: Years 11 and 12 mathematics course selections

<table>
<thead>
<tr>
<th>Mathematics course</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics General 1 (non ATAR)</td>
<td>16.2</td>
</tr>
<tr>
<td>Mathematics General 2 (ATAR)</td>
<td>51.5</td>
</tr>
<tr>
<td>Mathematics 2 unit</td>
<td>21.2</td>
</tr>
<tr>
<td>Mathematics Extension 1 (3 units of mathematics)</td>
<td>11.1</td>
</tr>
<tr>
<td>Mathematics Extension 2 (4 units of mathematics)</td>
<td>0</td>
</tr>
</tbody>
</table>

The most preferred student choice was the mathematics general 2 course as it contributed toward the students’ Australian Tertiary Entrance Rank (ATAR) however, it was not considered as challenging as the 2 unit mathematics course. In the questionnaire, no students expressed an interest in mathematics extension 2 however, during their interview, two Year 11 students explained that their examination results in the preliminary course would determine whether they would select mathematics extension 2 for Year 12.

Mathematics course preferences – interviewed students.

Interview data analysis revealed the course preferences of Years 10 and 11 students and these results appear in Table 6.11. Two Year 11 students and one Year 10 student reported that they were not continuing with mathematics in the following year.
Table 6.11: Years 10 and 11 student mathematics course preferences

<table>
<thead>
<tr>
<th>Mathematics course</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>General mathematics 2</td>
<td>7</td>
</tr>
<tr>
<td>Mathematics 2 unit</td>
<td>5</td>
</tr>
<tr>
<td>Extension 1</td>
<td>11</td>
</tr>
<tr>
<td>No mathematics</td>
<td>3</td>
</tr>
</tbody>
</table>

Interview data analysis revealed that 62% of the Year 10 and 11 students had selected mathematics 2 unit or mathematics extension 1 course, both challenging courses. The interview also provided an opportunity to explore the reasons why students wished to select or not select a mathematics course in Years 11 and 12.

**Reasons for selection of a mathematics course in Years 11 and 12.**

The emphasis on the usefulness of mathematics was the most common reason for students selecting a mathematics course. Elizabeth and Anastasia explain their reasons:

Maths plays a big role in everyday life. My Dad’s a builder and he uses it every day. My mum’s an exercise physiologist; she also uses it. So I feel like if you have that knowledge it just makes everything a lot easier. I wasn’t going to take Maths but as I look now into jobs that I’d like to do it’s good to know Maths and have that knowledge. (Elizabeth10)

I know that every job requires Maths at some stage. If you don’t take Maths you can be stuck. No matter what I want to do with my future, if I have Maths as something that I can do, then I’ll be able to really do a lot of things. (Anastasia8)

Bronwyn’s thoughts on working hard showed that she was oriented toward learning goals. She explained:

Because I’m always, it’s been a subject that I have enjoyed, and it’s a subject that because I’m especially doing Extension, I believe that I will have to put a lot of effort in and work
hard, and I think that Maths would be one of the subjects that I would be willing to do that for. (Bronwyn10)

Several students baulked at attempting a higher level of mathematics even though they were currently doing well in the subject. Excerpts from the interview data suggest that these students may have a more fixed mathematics mindset as they expressed concern with the possible workload that may ensue either from the belief of not having enough ability or not being able to develop this ability. The student responses reflected performance (looking smart) goals rather than mastery goals. Shiobhan favoured mathematics but was reluctant to take on a more challenging course. She stated:

    Well, I’ve always favoured Maths more, I’ve always liked the fact that it’s different from all other subjects, like it’s more unique. I am taking Maths next year, I’m doing general 2. I was going to do mathematics extension but I thought that might be a little too much pressure on me. (Shiobhan10)

Likewise, Sandra was ranked sixth in her class in general mathematics and despite being encouraged by her teacher to enroll in the 2 unit mathematics course, she decided not to extend herself further. She added:

    General 2 Maths, I thought like I better not push myself. I just thought I’ll just stick to the basic kind of stuff just to be sure. (Sandra11)

In the interview, Eileen repeatedly mentioned there were limits to developing intelligence or ability and this belief was demonstrated in the following comment.

    There’s no point really stressing over trying to learn mathematics. I’m just going to do General and know that I can do it. I suppose you could say I’ve almost put a limit on myself there. (Eileen10)

Eileen was a high achiever and as she struggled in mathematics in Year 10 she did not want to risk her grade average. She did not believe that her ability in mathematics could be developed
enough to achieve above satisfactory grades. Performing well in a less demanding course was more preferable for Eileen, than “taking on” the more challenging course.

These student responses are indicative of the manner in which mindset can affect participation in mathematics. Students who preferred to succeed in a less challenging course rather than select the more difficult course have adopted performance goals rather than learning goals. Performance goals are about winning positive judgments of your competence, in this case in mathematics and avoiding negative ones. When students pursue performance goals they’re concerned with their level of intelligence and they want to look smart. There is less risk of failure or ‘underperformance’ in an easier course. These students on the whole could be best described as being academically bright as indicated by their average “A” grade on school reports, however this was not transferring to the selection of more advanced mathematics courses.

**Reasons for non-selection of a mathematics course.**

Interview analysis of data also revealed that seven students (16%) from Years 7 to 11 decided not to select mathematics for Year 11 and 12. Their reasons are recorded in Table 6.12.

**Table 6.12: Reasons for non-selection of a mathematics course**

<table>
<thead>
<tr>
<th>Reasons</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not very good at mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Harder than other subjects</td>
<td>2</td>
</tr>
<tr>
<td>Not interesting/don’t enjoy it</td>
<td>1</td>
</tr>
<tr>
<td>Too theoretical (need more hands on)</td>
<td>1</td>
</tr>
</tbody>
</table>

Kathleen in Year 9 had already decided not to pursue mathematics in Years 11 and 12. The current grading of mathematics and her placement in streamed classes has obviously made an impact on her decision not to further pursue mathematics in the senior years. She pointed out:

Maybe because I’m not very good at Maths. Like Year 7 I started in the middle class and then I got moved down to the bottom class. Year 8 I went to the middle class again and this year I’m in the bottom class. (Kathleen9)
Sharon, felt that she should select mathematics in the senior years because of the usefulness of the subject, however she was already of the opinion that it was “not for her”. She emphasised her lack of interest in and difficulty with the subject. Sharon stated:

I think I probably should take it but I don’t really want to. Just because it’d be helpful with different careers and opportunities that it would bring, being able to have a better knowledge of advanced Maths, I guess. It’s just, I don’t find it very interesting and it’s pretty, I find it harder than a lot of other subjects. (Sharon8)

Students who struggled with mathematics, and found the subject more difficult than their other subjects may doubt their intelligence or ability in mathematics. The belief of a limited and unchangeable ability makes the student question whether future effort is worthwhile.

Mathematics participation (engagement) in Years 11 and 12.

This section reports the questionnaire findings relating to students’ engagement in mathematics by examining the:

- mathematics engagement scale; and
- relationship (correlation) between mindset scales and mathematics engagement scale.

The findings from the interviews gave evidence to explain students’:

- mathematics engagement; and
- self-reported learning behaviours in mathematics.

The findings from the questionnaire and interviews follow.

School sample – Mathematics engagement scale.

The three questions relating to interest, enjoyment and belonging in the questionnaire constitute the mathematics engagement scale. In order to investigate whether there was a significant statistical difference in the mean scores for mathematics engagement for students who selected to take mathematics in Year 11 and 12 and for those students who did not, an
independent samples t-test was conducted. As the significance value for the Levene’s test is larger than .05 (.09 in this case), equal variances were assumed. The summary statistics and the independent t test result are shown in Table 6.13 and 6.14 respectively.

**Table 6.13: Group statistics**

<table>
<thead>
<tr>
<th></th>
<th>Do you think that you will choose Maths in Year 11 or 12?</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maths engagement</td>
<td>Yes</td>
<td>364</td>
<td>8.33</td>
<td>2.15</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>103</td>
<td>5.78</td>
<td>2.24</td>
<td>.22</td>
</tr>
</tbody>
</table>

**Table 6.14: Independent samples test**

<table>
<thead>
<tr>
<th>Maths Engagement in class.</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>2.1</td>
<td>.15</td>
</tr>
</tbody>
</table>

The results of the independent t-test indicated there was a significant difference in mathematics engagement for students who selected a mathematics course in Year 11 or 12 (M = 8.33, SD = 2.15) and those students who did not select a mathematics course in Year 11 or 12 (M = 5.78, SD = 2.24; t (465) = 10.54, p = .00, two-tailed). The magnitude of the differences in the means (mean difference = 2.6, 95% CI: 2.08 to 3.03 was large (eta squared = .19).

Mathematics engagement was higher for students who participated in or would be studying a mathematics course in Years 11 and 12. This result suggests that students who have selected a mathematics course for the senior years would express a greater liking, more interest and a
stronger sense of belonging in the subject compared to students who chose not to select a mathematics course.

*Correlation analysis of mindset scales with mathematics engagement scale.*

Pearson’s correlation coefficient was calculated to describe the strength and direction of the linear relationship between mathematics engagement and the mindset scales. The results of each of the correlations were significant at the .01 level (two-tailed) and appear in Table 6.15.

**Table 6.15: Correlational of mindset scales with mathematics engagement scale.**

<table>
<thead>
<tr>
<th>Mindset scales</th>
<th>Pearson’s correlation coefficient</th>
<th>Significance (2 – tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General growth</td>
<td>.28</td>
<td>.00</td>
</tr>
<tr>
<td>2. Mathematics growth</td>
<td>.47</td>
<td>.00</td>
</tr>
<tr>
<td>3. English growth</td>
<td>.22</td>
<td>.00</td>
</tr>
</tbody>
</table>

As illustrated in Table 6.15, for general growth mindset, there was a small, positive significant relationship between the two variables, $r = .28$, $n=472$, $p < .00$. The coefficient of determination was $(.28 \times .28 = .08)$. General growth mindset helps to explain nearly 8 per cent of the variance in students’ scores on mathematics engagement scale. It is suggested that students with a high growth mindset might be expected to also have high mathematics engagement.

For mathematics growth mindset, there was a medium, positive significant correlation between the two variables, $r = .47$, $n = 468$, $p < .00$. The coefficient of determination was $(.47 \times .47 = .22)$. Mathematics growth mindset helps to explain nearly 22% of the variance in students’ scores on the mathematics engagement scale. It is suggested that students with a high mathematics growth mindset might be expected to also have high mathematics engagement. The mathematics growth mindset of students showed a stronger relationship to mathematics engagement than general growth mindset. It is suggested that students who believed they could develop their mathematical ability by effort were more likely to enjoy mathematics, find it interesting and express a sense of belonging in the mathematics classroom.
For English growth mindset, there was a positive significant relationship between the two variables. The coefficient of determination was (.22 x .22 = .05). English growth mindset helped to explain 5% of the variance in respondents’ scores on the mathematics engagement scale. It is of note here that those students with a high English growth mindset might also be engaged in mathematics. These results may reflect a positive flow on effect of having a growth mindset in general or in a particular subject influencing another subject with beneficial effects, in this case, engagement in mathematics.

Mathematics participation (engagement) - interviewed students.

Interview data analysis revealed that 39 students (87%) liked mathematics with only six students disagreeing. The reasons students gave for liking the subject were the nature of mathematics itself, its usefulness in everyday life, students’ success in mathematics and enjoyment of the challenges mathematics presents. The following excerpts from the interviews are examples of the students’ explanations of liking mathematics.

Marilyn emphasised her success in the subject:

I like mathematics because I’m good at it, I quite like it. Because I can succeed in it.

(Marilyn10)

Carmen based her response on interest:

I do like Maths. I think it’s interesting how everything fits together nice and logical.

(Carmen11)

Julie shared her opinion on the enjoyment of challenge:

But Maths is fun because it’s challenging as well and I enjoy that. I feel as though a lot of humanitarian subjects I can walk in there and it’s a lot more relaxed and a bit easier, but Maths is challenging and I enjoy that. (Julie11)

Ellen pointed out the usefulness of mathematics:
It is something that you do need to know throughout your life, because it won’t just go away. Like there are problems that you face in life and you need to know and be able to work them out. (Ellen8)

Barbara felt that it was important to belong in the class and feel comfortable. She expressed her views as follows:

I think it’s being able to work with like-minded people and if you can’t, if you don’t know how to work it out you can go, “Oh, how did you work it out?” I go, “Oh, I did it like this”. And they’ll step you through it, and you can do the same for them. (Barbara10)

The students who voiced little or no enjoyment of mathematics emphasised its difficult nature, and their lack of interest and disconnect with the subject. Several students shared their struggle with the subject as typified by Margaret and Sharon’s comment:

I don’t really want to work, I don’t want to study for it; I just don’t get it; like I struggle with it definitively. (Margaret10)

I find it harder than a lot of other subjects. I tried really hard at it but it just doesn’t seem to make sense. It’s hard for me to understand it. I don’t find it very interesting. (Sharon8)

Interview data analysis revealed that student definitions of mathematics engagement were similar to the engagement questions in the questionnaire. Students emphasised their like or dislike of mathematics, level of interest, and whether they fitted in the subject. Further factors such as standard of achievement, the difficulty of the subject, and family, peers and teacher influences came into play as to whether students thought it was worthwhile persevering in mathematics.

**Mathematics engagement and self-reported learning behaviours.**

Interview data analysis revealed active engagement in mathematics. 89% of the students emphasised effort as their main way to improve in the subject. Memorisation of formulas and rules were given priority as Patricia’s response exemplifies:
I find once I understand ... for example, if I get a formula in class and I go over it a couple of times, once I know how to do it, then I’m all right. Once you get the idea and you keep going that helps, but if you give up it’s not going to work (Patricia9).

Practise and repetition were other means students identified as active engagement in mathematics as mentioned by Year 11 students, Morwenna and Olivia. They stated:

Just I think the only way to get better at Maths, because you can’t really write notes for it as such, you can’t write sentences, unlike other subjects. You have to actually do the questions and just practise the questions. (Morwenna11)

Maths, I found it’s more about repetition and using the formulas and practising them, than anything else. (Olivia11)

Interview data analysis also revealed that nine students (20%) viewed their active engagement in mathematics as seeking help from teachers, parents, tutors or siblings in order to understand the content of the course. In the quest for understanding, Stephanie does not hesitate to ask for help.

Speaking to your teacher and trying to understand what you’ve been taught. Talk to parents. Or you could ask your friend I guess who’s in your class, ask them to explain it a bit more. (Stephanie8)

Profiling students.

In this last section, trends that emerged from the profiling of students who did not select mathematics in Years 11 and 12 and those students who selected more challenging mathematics courses are presented. Interview data analysis enabled an exploration of the possible differences in mindset. The trends that emerged were as follows.

Profile of students not selecting mathematics in Year 11 and 12.

Seven of 45 students (16%) expressed their decision not to select mathematics in the senior years. The interview with each of these students enabled the researcher to explore their implicit beliefs about their ability in mathematics and their reasons for not wanting to pursue the subject
further. From the interviews with these seven students, several themes emerged that typified the mindset of non-participants in mathematics. In general, these students described their current achievement in mathematics as “average, just OK, not very good at Maths”. These students spoke of mathematics as not being of interest, sometimes boring and difficult to understand. Judith, expressed her opinion that mathematics was hard to understand in comparison to her other subjects and she explained it in terms of how the brain had to work in mathematics. She stated:

    Well, I guess you’re using your brain a lot to figure out the answer or whatever. But with other subjects it’s more remembering, if you get what I mean. Like with history you can remember dates and stuff. But Maths you’ve got to do that sort of stuff. (Judith7)

A common view expressed by these students was that mathematics was not a very creative subject, had lots of rules and seemed irrelevant. Their lack of natural ability in mathematics was mentioned by four of the seven students. Marlene described this natural talent for mathematics.

    It means that maybe you have a talent for it. So what some people might find a bit trickier and might take them longer to do, you find you’re able to do it quickly and efficiently. And generally enjoyable, I find, that people who are naturally good at things, enjoy that thing. (Marlene8)

One student argued that mathematical ability was formed throughout your life with no mention of innateness and one student believed that mathematical ability was innate. The remaining five students expressed the belief that mathematical ability was initially innate which could be grown or developed through learning and effort. Margaret, was not sure of being able to develop her ability in mathematics, however, improvement in mathematics grades was possible but it was from the perspective of other people helping not from her own efforts. She stated:

    Like I’ve never been very strong in Maths, I don’t really enjoy Maths, it doesn’t really interest me. I think it’s just remembering everything. In English everything’s a lot wordier like you can kind of just explain it a lot better. Maths is just very, you’re either wrong or right sort of thing. Tutoring would help, or just ask for the teacher’s help and get them to
explain it. Or you could ask your friend I guess who’s in your class, ask them to explain it to you a bit more. (Margaret10)

For several of these students, not having sufficient natural ability in mathematics meant increased effort and they were not confident of success. Nerida who was not going to continue with mathematics after the Year 11 Preliminary course pointed out that:

Some people are naturally smart and good at Maths and they can do it, other people work hard for it and that’s good, but other people it just doesn’t click, they’re just not going to get it. (Nerida11)

These students generally did not consider themselves confident in the subject, expressed some frustration with their work and added that they needed more time to comprehend and practice what was being learnt. All the students agreed that their results in mathematics could be improved by working harder but were unsure whether their increased effort would be rewarded with higher mathematics grades. Judith shared her concern:

I probably want to do more but if I actually can, I’m not quite sure about. (Judith7)

Two students regarded mathematics as a subject in which males tended to do well. Margaret justified her opinion by saying:

Oh, there’s that thing, yeah boys are probably better, I think. Yeah, I’ve definitely heard it said, like boys are definitely better. (Margaret10)

All the students concluded with the statement that although they were not considering studying mathematics in the senior years at this stage, success in the subject would influence their future participation. Kathleen highlighted this concern:

Well if you’re not very good at Maths you would want to get out of it as fast as you can. But if you like Maths then you want to continue it. (Kathleen9)
Profile of students who selected a high level mathematics course in Year 11 and 12.

Of the 17 Year 11 students interviewed, seven students were enrolled in Mathematics Extension 1 (3 units of mathematics) and two of these students were considering Extension 2 (4 units of mathematics) for the Year 12 Higher School Certificate (HSC), with the remaining students enrolled in mathematics 2 unit. The interview with each of these students enabled an exploration of implicit beliefs about their ability in mathematics and their reasons for wanting to pursue the subject further and at a higher level. From the 17 interviews several common themes emerged that typified the mindset of these participants in mathematics.

i) Challenging nature

Although these students thought that mathematics could be difficult and was not their easiest subject they emphasised enjoying the challenging nature of mathematics and the problem solving required. Melanie expressed her opinion as follows:

I do find it difficult, especially the Extension side. But I do like the challenge it presents. I don’t like just going through school having everything easy. Like it is good, but you do need some challenges. (Melanie11)

ii) Fun

The word fun was often mentioned. These students had a high level of engagement in mathematics such that they liked the subject and found it interesting. The point was made that “you didn’t have to write about your opinions in mathematics” and this was appreciated. Deborah11 described why she enjoyed Maths, as it was “all connected, straightforward and logical.”

iii) Level of current achievement

These students described their achievement as “doing reasonably well or good at Maths” and with better results in some topics than in others. Struggling in one area but achieving well in another did not discourage their optimism. An emphasis was given to understanding,
remembering and persevering which was best achieved by “practising your Maths”. Carmen thrived on hard work, describing it in the following manner:

   I think because it’s so hard I’ve had to work so much harder and I think that has motivated me to like, I have to work so much harder to do well and in doing that consciously I’ve just done well. (Carmen11)

Sometimes the students did not achieve as well as expected but were not discouraged. Susan became more determined when challenged in mathematics.

   It’s a challenge. There’s always something that you have to figure out. And if I get it wrong, I’m not discouraged by it; I want to know why I got it wrong and how to not get it wrong the next time. (Susan11)

*Natural talent*

Having a natural talent for mathematics was mentioned and several students identified themselves as having mathematical talent. Morwenna regarded herself as having this innate ability. She stated:

   It comes to me quite naturally, so I find it a lot easier than other people might. I’ve just sort of been good at Maths ever since I was young. (Morwenna11)

These students pointed out that people can be born with natural mathematical abilities or talents (innate), however mathematical knowledge and skills were developed over time by working hard. None of these Extension students argued for innate ability only as the main advantage in being successful at mathematics. Nor did any of these students suggest that effort only was responsible for success. Both innate ability and working hard were recognised as important in doing well in mathematics. Barbara explained:

   My parents were extremely good at Maths and they’re both accountants. I sort of think that’s part of genetics. There is an element of being born with it, but in saying that anyone can improve with Maths. I think putting the effort in... (Barbara10)

Deborah described it as follows:
I do think people have different abilities. I think everyone can develop it overtime. It’s just about how much work they put it, and effort, and if they like it or not and the perseverance. (Deborah11)

Wendy pointed out that ability was not enough, that it must be developed.

I think that ability does pay off, obviously for some people. But if you don’t keep using it and practising your ability it’s not going to stay there very well. (Wendy11)

The gender stereotype that boys were better than girls at mathematics was dismissed quite adamantly by these high achieving students. As Deborah pointed out:

Because, well, a female can do just as good as a male. It’s just how hard they work, I think, and their concentration. Whereas if you’re getting distracted all the time then I think that’s just the same. (Deborah11)

Julie argued for individual differences amongst people. She stated:

From what I know I don’t think it’s very gender related. I think it depends on the beliefs of the individual person. And sometimes that may change because of influential people in that individual’s life. (Julie11)

Carmen spoke of the different maturity levels of boys and girls and that this might make a difference, but added:

I think everybody can learn at the same rate and can work, like work hard equally sort of thing. (Carmen11)

Susan commented on males choosing mathematics more often than females but did not think that males were better at the subject. She stated:

It’s kind of generalised that males are better at Maths than females and I don’t think that’s true. I just think a lot more males choose to do Maths more than females and that’s why they seem better at it. (Susan11)

The discussion of these findings is addressed in Chapter Seven.
Chapter Seven: Discussion

Mindset and Mathematics

The main purpose of this chapter is to discuss the findings represented in Chapter Six. These findings related to i) the implicit theories of intelligence specifically related to mathematics held by a sample of female secondary school students and ii) the relationships between students’ beliefs and their participation in mathematics in Years 11 and 12.

Implicit Theories of Intelligence Related to Mathematics

Findings from the data analysis for the school sample revealed a significant difference in the mathematics growth mindset mean compared to the means of general growth mindset and English growth mindset. The mathematics growth mindset mean was lower than the general and English growth mindset mean. This significant difference is a key result that has implications for students’ future participation in mathematics. The findings imply that students have a more fixed mindset for mathematics. The lower mathematics growth mindset mean, may reflect the students’ beliefs that success in mathematics is more contingent on ability, and their reservations regarding whether their ability can be developed. Students who fail to achieve high grades in mathematics in the junior years and do not believe that they can develop their mathematical intelligence, may be more likely to question the worth of pursuing the subject in the non-compulsory years.

The analysis of interview data helped to shed light on this significantly lower mathematics growth mindset mean. As was reported in Chapter Six, only one student viewed mathematics intelligence as completely innate and stable; an ability she argued she did not possess. The remaining students were divided equally in their ability beliefs. Forty nine percent of students believed that mathematical ability was not innate but developed by effort and learning throughout life, and 49% of students emphasised that mathematical ability was innate however, could be further developed. This latter belief, may lead students to question how much natural mathematical ability they possess and how much growth in their mathematical ability was possible. Although
allowing for later growth this latter belief may have at its core fixed mindset thinking, particularly where limits or a ceiling are placed on students’ level of improvement. Mendick (2008) describes the perception that people have of *mathematical ceilings*; the idea that only some people can do high-level mathematics and this ability resides within them as if there were a “*mathematics gene*” and so it is “accepted as natural rather than socially constructed” (p. 727). Mathematics may therefore be regarded as ‘not for everyone’ and high mathematical achievement may be viewed as a signifier of high intelligence.

The students who believed that intelligence could only be developed by effort with no innate beliefs would not be as vulnerable to ability beliefs compared to those student who believed in innate ability. It is the emphasis given to an innate component which is arguably the problematic factor. Whether the effort leads to successful achievement is the *Achilles heel* for mindset in the long term. The teacher has an important role in ensuring that students are taught effective strategies to make effort productive, leading to improved results and helping to develop a growth mindset in the long term. The types of effort required to learn mathematics would need to be detailed and scaffolded with explicit feedback provided by the teacher in order to improve the student’s achievement and ability in mathematics over time. Attard (2013) emphasised that “positive pedagogical relationships between teachers and their students must be developed as a foundation of sustained engagement” (p. 569).

The 49% of students with beliefs in innate ability which could be improved by effort, may develop either a fixed or growth mindset over time as illustrated in Figure 7.1

![Figure 7.1: Dynamic mindsets](image)

<table>
<thead>
<tr>
<th>Fixed mindset</th>
<th>Continuum of innate developed beliefs</th>
<th>Growth mindset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innate ability</td>
<td>How much natural ability do I have? Develop ability through effort</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How much can I develop my ability?</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.1: Dynamic mindsets
Nardi and Steward’s study (2003) found students’ self-images of mathematical ability were overwhelmingly negative with some students suggesting that mathematical ability was innate and therefore more committed engagement would not necessarily yield a better performance. Initially, interview conversations with students were quite positive and suggested that most students had a strong growth mindset for mathematics. However on further investigation, there was a ‘façade’ of a mathematical growth mindset by some students particularly those who believed in innate mathematical ability which could be developed by effort. The emphasis given to natural mathematical ability implied more fixed beliefs perhaps than the student intended. Four of the seven students who did not wish to continue with mathematics in Years 11 and 12 had the belief that ability was innate but could be developed and one of the seven had a fixed mindset for mathematics. For these five students there was a lack of confidence or ‘know how’ in being able to develop their mathematical ability or potential. The remaining two students who did not wish to continue in mathematics believed in full development of mathematical ability by learning and effort but volunteered their lack of interest and lack of enjoyment as their reasons for non-participation in mathematics at the senior level. Their apparent growth mindset was not enough to convince them to take on the challenges of senior mathematics. Arguably not all students who have a mathematics growth mindset in junior secondary will extend their mathematics education, as enjoyment and interest in the subject or the lack thereof featured predominantly in students’ comments.

Cassandra, a Year 11 student who was achieving commendably in mathematics 2 unit and now in Extension 2 was mentioned in Chapter Four. The student defended her success in mathematics as a product of her hard work not ability. She doubted her mathematical ability as she had to work so hard pointing to her brothers’ seemingly effortless mathematics achievements. This may be an example of the imposter phenomenon or syndrome (Clance & Imes; 1978; Clance, 1985). Cassandra’s beliefs were similar to those posited by Ivie et al. (2016) that:

People with the imposter syndrome can also discount their successes by attributing them to hard work, while believing that others sail through based on natural talent. (p. 3)
Imposters may tend to be perfectionists due to their high expectations and their need to prove themselves resulting in higher grades. Perhaps the student felt that in working hard she was not ‘genuinely intelligent’ at mathematics, regarding herself as ‘cheating’ to obtain the excellent results. Interestingly, although Cassandra believed that mathematical ability could be developed by working hard in mathematics she also believed that there was a strong innate component, revealing the ‘mixed’ growth mindset.

Again, Dweck (2000, 2006) is able to explain this result in terms of a student’s intelligence mindset. She argues that bright girls may be the most not the least vulnerable to doubts about their ability, as it is important for them to continue to be smart. As a group they generally perform well in primary school and junior secondary school by readily mastering what is required. However, in the more challenging upper secondary environment when presented with challenge or obstacles bright girls may blame their ability, preferring to take on a less challenging task or avoid the challenge all together. As Dweck (2000) points out:

Bright girls know they are bright and successful but only up to a point, for in this self-measurement framework, you’re only as good as your last success ... a history of brightness and success is no guarantee of a mastery-oriented response to challenge. (p. 55)

In Cassandra’s case she was prepared to take on the challenge of high level mathematics in Years 11 and 12, unfortunately she may not select STEM subjects at university, ruling herself out on the belief of ‘absence of talent or brilliance’.

Doubts about their mathematical intelligence were sometimes expressed by students during the course of the interview and may be linked to the questioning of their natural ability and of not really understanding mathematics. Unfortunately, Good et al. (2008) disclosed that even though female students may be relatively successful at mathematics, they do not perceive themselves to be good at the subject. Howe and Berenson (2003) report the desire of girls to understand mathematics mentioning that some students disclosed that “they want to know how problems work not just how to work problems and get the right answers” (p. 7). Mendick (2005b) mentions that females want real understanding not just rote learning. Steele et al. (2008) further agree
that mathematics is valued most when it is understood. Girls develop a preference which Boaler (2002) calls a “quest for understanding” (p. 133). Boaler (2002) in her longitudinal study with 300 students in two secondary schools in England over a three year period, reported that girls sought a deep, conceptual understanding of mathematics. Girls wanted to understand the connections between mathematical methods and why they worked and they were not content to manipulate abstract methods without considering their connections or relations. Boaler, reported that girls employing a procedure-oriented mathematics approach at one of the secondary schools became disaffected with this traditional mathematics pedagogy. The findings of the data analysis for this current research study illustrated many examples of student efforts in class and these were also generally of the procedural, consolidation variety with some general dissatisfaction expressed by the students of these meaningless practice tasks which is in accordance with the findings of Boaler.

Some of the interviewed students mentioned their difficulty in understanding mathematics particularly when they had to give an answer quickly and thought that this reflected on their lack of ability. According to Attard (2012), “students’ experiences of mathematics should combine a focus on learning and a pleasant classroom experience” (p. 12). For many students the fast paced mathematics classroom is anything but a pleasant experience. Boaler et al. (2000) agree that the mathematics classroom can be fast paced and this is incompatible with understanding. Boaler (2016) believes that mathematics, more than any other subject, seems to promote speed as important and consequently the depth of understanding suffers. Girls may find it difficult to persevere with a subject they do not fully understand. Attard (2010) also found the increased pace of mathematics classes in secondary affected student engagement in mathematics and noted that “Year 7 students felt pressure to complete work within a limited time frame, and although they claim they were familiar with the content, this appeared to have had a negative effect on their engagement in mathematics” (p. 56).

The top or advanced classes in mathematics can be fast, procedural and competitive which can mitigate against some students achieving well. According to Attard (2010), the more competitive and norm referenced assessment practices in secondary mathematics compared to primary classes lead to lower mathematics engagement. Disengaged students not achieving well in
mathematics would undoubtedly question their mathematics ability. Boaler (2016) further emphasised the need for all students to have a strong growth mindset:

We need students to have growth beliefs about themselves and accompany these with growth beliefs about the nature of mathematics and their role within it. With conceptual, investigative mathematics teaching and mindset encouragement, students will learn to shed harmful ideas that mathematics is about speed and memory and that they get it or don’t. (p. 55)

**The role of effort in mathematics.**

Overall students recognised the importance of effort in improving mathematical outcomes and grades. Similar to the study by Howe and Berenson (2003), the interviews confirmed that most girls believed that success in mathematics came from hard work rather than ability. For some students, the belief in an innate component of intelligence made the student more vulnerable when the work was more challenging and achievement was poor as it raised doubts of the *amount of their ability*, rather than reviewing their efforts. Generally the interviewed students agreed that it was accepted by their peers that there was a necessity to work hard in mathematics and this attitude is supported by the research literature. A common belief of female high achievers is that a “good Math’s student is one who tries hard and does their best” (Howe & Berenson, 2003, p. 6). Work and diligence were associated with being a girl (Brandell & Staberg, 2008). However, this research did not provide evidence to support Covington and Omelich (1979)’s work that illustrated that it was more socially acceptable for the students not to try, rather than to try hard and perform poorly – the “double edged sword” or Sullivan et al.’s (2006) study that reported students’ awareness of some peer pressure to appear not to try hard. The effortless achiever was not admired as was the case in Jackson and Nyström’s (2014) study, interrogating discourses about effort and effortlessness in Swedish and English upper secondary schools.

Student interview responses provided evidence of a reasonably strong work ethic which may be more typical of females in a single-sex school rather than a co-educational environment. Tully
and Jacobs (2010) report that single sex schools are of benefit to girls as the context improves their self-belief, confidence and achievement. Interestingly, Eisenkopf et al. (2015) found that female students educated in single-sex classes, as compared to female students assigned to coeducational classes, evaluate their mathematics skills more positively and are more likely to attribute their achievement in mathematics to their own efforts rather than to talent or luck. However, Bornholt and Moller (2003) found that profiles of attributions about doing well in mathematics and English were remarkably similar for girls and boys at co-educational and single-sex schools. Their study revealed that adolescents consider “that long and short term effort are the most important reasons for success and failure in mathematics and English” (p. 222). This conclusion concurs with my findings from the school sample and interview sub-sample. Overall the students believed that success came from hard work rather than ability and this corresponds with Howe and Berenson’s (2003) study on high achieving girls in mathematics. This was also a finding consistent with the OECD (2014), claim that:

"Practice and hard work go a long way towards developing each student’s potential, but students can only achieve at the highest levels when they believe that they are in control of their success and that they are capable of achieving at high levels. (p. 21)"

Shanghai-China student results in PISA 2012 (OECD, 2014), were the highest scores in mathematics; 119 points above the OECD average. These students expressed a high work ethic and beliefs in the control of their ability to succeed. When students believe that investing effort in learning will make a difference, they score significantly higher in mathematics.

Students are also influenced by parental expectations and Räty et al. (2002) report from their Finnish study that often parents have “classic gender-related attribution patterns” explaining their son’s success in mathematics to talent and their daughter’s to effort (p. 121). The students may in part be conditioned by their parent’s expectation that girls have to work hard in mathematics to achieve success, as subconsciously they may not all believe they have the natural talent associated with males in the subject.

The students who believed in innate mathematical ability, which was further developed by effort and learning (nature + nurture) for being capable at mathematics sometimes questioned the role
of effort. Their dilemma occurred when the subject was found to be difficult and the student had to work hard to achieve pass results. Their concerns which were raised in the interview were; “What did having to work hard imply for them?”, “Was needing to increase their efforts related to their lack of ability even though they recognised that effort could develop their ability?”, “How much could they really develop their ability?” Whether the student found mathematics to be a difficult or challenging subject and her achievement or lack of achievement was a tipping point for how effort was viewed or valued. The mindset that combined the belief in innate ability initially plus growth in this ability by effort (which I have named a mixed or combination growth mindset), may not be enough to stave off concerns or anxiety about their mathematical intelligence. Depending on the whole set of beliefs a student had, it might not be limiting to believe that people have different innate abilities which develop. We all commence at different points in our mental development as young children but a growth mindset for mathematics will depend on the students’ accompanying beliefs about their potential for ability growth and the success of effort in mathematics. Dweck (2006) acknowledged a genetic component but emphasised the role of effort:

Each person has a unique genetic endowment; people may start with different temperaments and different aptitudes, but it is clear that experience, training and personal effort take them the rest of the way. (p. 5)

The problem however, for some students and perhaps their parents and families stems from the emphasis given to the genetic or innate component at the expense of developing potential. As with general intelligence, effort required in mathematics could have positive or negative connotations depending on students’ mathematical mindset. In an entity framework, having to work hard in mathematics could imply a deficit of ability (inverse relationship), or in an incremental framework, in which working hard may be recognised as necessary in developing ability (positive relationship). These two different relationships of effort and ability were not always distinct in student responses as sometimes both beliefs were interwoven or held by the one student. Effort beliefs may not be as straightforward or as clear cut as noted in the research literature. Interview data analysis revealed that a student may hold both beliefs about effort and ability at different times depending on the success of their efforts in a particular mathematics
topic. Interview data analysis also revealed that different topics in mathematics evoked different ability and effort relationships and this varied from student to student. Mercer and Ryan (2010) found evidence of learners having differing mindsets across different domains such as music, sport, geography and language learning. At the skill-domain level in the learning of foreign languages a further sublevel of skill-specific mindset beliefs may be held by the student. Mercer and Ryan provide the example that a learner’s mindset relating to speaking skills could possibly differ from their mindset to writing. As applied to mathematics, different topics seemed to elicit different mindset responses. Students gave examples of believing they could develop their ability in algebra for example, but not in geometry and so they would work harder in algebra with consequent better results.

**Participation in mathematics – course selection.**

Data analysis revealed that over a fifth of the school sample would not be selecting mathematics for Years 11 and 12 or are currently not studying mathematics. This decision may severely limit their career options and life chances. Watt (2005) points out that females who discontinue their mathematical studies earlier than males may be less likely to attain highly prestigious and highly paid jobs that depend on prior mathematics. The students’ self-perceptions about their own mathematical ability and expectations for mathematical success may underpin their deselection from mathematics and thus they would be more likely to choose other subjects. Students who view their mathematical ability as fixed would be more likely to disengage from mathematics following poor results in Years 9 and 10 (middle school).

Overall the students who selected a mathematics course for Years 11 and 12 had a higher mathematics growth mindset than students who did not wish to take on more study in mathematics at the senior level. This finding is extremely important as it revealed that participation in mathematics was significantly related to a growth mindset. Students who have a growth mindset for mathematics might be more likely to participate in mathematics courses for Years 11 and 12. For schools in general, the development of students’ mathematics growth mindset may be beneficial in increasing senior mathematics participation. Students with a growth mindset perceive intelligence or their abilities in a given area as being able to be developed.
These students often show a mastery oriented response and apply themselves more to their work particularly when the task is difficult or challenging (Blackwell et al., 2007; Dweck, 2000, 2006; Good et al., 2003; Romero et al., 2014). Students who intend studying a mathematics course in Year 11 and 12 with the knowledge that the study of mathematics can be challenging, would have a higher growth mindset for mathematics than those students who do not intend taking mathematics in Year 11 and 12.

If by Year 10, students have fixed mathematical mindsets then they might be less likely to select a mathematics course for the senior years. Romero et al. (2014) found that students who believed their intelligence could be developed were more likely to move to advanced mathematics courses over time. Ideally for successful achievement in mathematics, students should be encouraged or taught to associate effort in mathematics with mastery goals and competency beliefs rather than performance goals and ability beliefs. Boaler (2016) argues that early in schooling it is critical that parents and teachers introduce mathematics as a flexible, conceptual subject that is all about “thinking and sense making” (p. 35). Murray (2011a) noted in her study that students showed strong emotional responses towards mathematics and for some there was a sense that they had “lost their way in the subject in earlier years; these students expressed a sense of regret, loss and even anger” (p. 283). Furthermore, Grootenboer (2013) mentions that “historically many students have left school with debilitating views of the subject” (p. 321).

A finding from the data analysis revealed that over 67% of the school sample in Years 10 to 12 had selected or would select General Mathematics 1 or 2 for the senior years. The majority of the students preferred to study the less demanding General mathematics courses rather than the more challenging Mathematics 2 unit and Extension 1 or 2. This finding was most likely linked to the significantly lower mathematics growth mindset mean compared to general growth mindset and English growth mindset means for the school sample. The majority of students did not have a strong enough belief that they could develop their ability or intelligence in mathematics to succeed at a more challenging level. The students may have felt that it was not worth their efforts which Lüftenegger and Chen (2017) refer to as cost value beliefs. The finding
may further indicate that students who preferred to succeed in a less challenging course may have a preference for performance goals – looking smart, rather than learning goals which is more indicative of fixed mindsets.

There is also a possibility that some students are abandoning the more complex 2 unit HSC Mathematics course in favour of the less demanding General course in an attempt to maximize their Australian Tertiary Admission Rank (ATAR). This decision may back-fire on students as they may think that “I don’t need to work very hard in this subject because it’s the easy Maths”, resulting in disappointingly low marks and consequently a lower ATAR. The significantly lower mathematics growth mindset for the school sample compared to general growth and English growth mindset has implications for students progressing further in mathematics at the senior level, for future tertiary study and possible career choices.

**Participation in mathematics – engagement.**

Data analysis indicated that the student’s mathematics mindset played a very important and powerful role in determining whether a student continued with mathematics in the senior years, their selection of course level and their engagement in learning.

Mathematics engagement was significantly higher for students who had already selected mathematics for Years 11 and 12 and for junior students who had the intention to do so, as compared to students who had no intention of continuing with post-compulsory mathematics. Mathematics growth mindset had a significant positive relationship with mathematics engagement, however, cause and effect cannot be determined. Does being engaged in mathematics help to develop a mathematics growth mindset or does a mathematics growth mindset enable greater engagement? I would suggest that both are mutually reinforcing, each leading to gains in the other.

Interview data analysis revealed that the majority of students liked mathematics and depending on the topic found it interesting. As a whole group they generally expressed positive values about the usefulness of the subject in everyday life and future careers. This result was contrary to the popular myth that girls do not like or are not good at mathematics. The data revealed that the
The Year 11 students who had decided to enroll in Extension 2 mathematics would do so only if they had a close friend in the course. Feeling comfortable with a known person and being able to work together were the deciding factors in moving from Extension 1 to the more challenging Extension 2 mathematics where the number of participants was small (usually no more than 5 students).

The findings from the data analysis of the school sample indicated that 77% of students would select mathematics in Years 11 and 12, however, Year 10 to 12 course selection indicated that this would not be at the more advanced levels as evidenced by the high enrolment in the less challenging General mathematics courses. As mentioned previously this result may be a reflection of the significantly lower mathematical growth mindset than general growth mindset for the school sample. Meyer et al.’s (2015) theoretical model posits that ability beliefs do drive females’ educational and career choices and this is supported by this study’s findings from the questionnaire and interviews. Van Tuijl and van Molen (2015) suggest that to prevent students dropping STEM subjects, particularly mathematics, attention needs to be focused on developing fixed and mixed growth mindsets into genuine mathematics growth mindsets early in high school or late primary school. Students generally regard mathematics as a complex subject that needs extensive effort to succeed. If they have a fixed mindset then they will be most at risk of ‘leaking out’ of the STEM pipeline. I would further argue, that these are the students with mixed or combination (innate + development) growth beliefs. Potentially the latter students may fall back into a fixed mindset with ineffective effort and low achievement or with successful strategies and positive outcomes may continue to develop a growth mindset.

This study extends the work of Burns and Isbell’s (2007) study of domain specific theories by explicitly comparing mathematics intelligence to intelligence in general. Shively and Ryan (2013)
in their study of College algebra students also found that students were consistently more growth oriented in their views of general intelligence, in comparison to mathematics intelligence.

The findings related to mathematics mindset raises questions about student perceptions of the factors influencing their beliefs about intelligence in general, and ability in mathematics. These findings will be reported in the next chapter.
Chapter Eight: Results

Student Perceptions of Factors Influencing Mindset

Chapter Eight is the final results chapter and presents the findings related to the following research question: What are students’ perceptions of the factors influencing their implicit beliefs about intelligence in general, and ability in mathematics?

The research question acts as an organising principle for the presentation of the results from the data analysis. The data for this chapter were derived from an analysis of two sources:

i) students’ responses to the Mathematics and Mindset Questionnaire; and

ii) face to face interviews with a subset of 45 students from the sampled population.

As described in Chapter Three, 487 female students from the selected secondary school in the NSW Central West, completed the Mathematics and Mindset questionnaire.

Introduction

Mindsets do not develop in a vacuum, but are the result of many closely interrelated factors such as broad cultural beliefs, parent/family influences and school related factors (Dweck, 2000; Wang & Degol, 2013). Mathematics can be seen to be linked to mindset in the following ways; i) the belief that mathematical achievement is linked to talent and being naturally good at the subject; ii) the belief that mathematics is regarded as a difficult subject to perform well in; and iii) the belief that males are better at mathematics than females. The following section on student perceptions of the factors influencing their implicit beliefs will contribute valuable insights into mindset research. According to Dweck (2007), the combination of viewing mathematics ability as innate, the belief that mathematics is difficult, and the stereotype of believing that girls are not good at mathematics, is a potent risk for girls. These self-defeating beliefs about ability result in decreased motivation and interest in pursuing mathematics in Years 11 and 12 and in girls’ future careers.
The findings from the questionnaire and interviews assisted in identifying student beliefs about the:

- ease or difficulty of mathematics as a subject and a comparison with English;
- gender stereotypes associated with mathematics and English;
- influences of peers, family and school related factors on their implicit beliefs of intelligence and ability in mathematics in particular; and
- influences of peers, family and school related factors on student participation in mathematics in Years 11 and 12.

The findings from the questionnaire and interviews follow.

**Ease or Difficulty of Mathematics as a Subject and Comparison with English**

The findings relating to student beliefs about the ease or difficulty of mathematics and English are presented under the following themes:

- school sample beliefs;
- the relationship between mindset scales and difficulty with mathematics;
- the relationship between mindset scales and difficulty with English; and
- interviewed students’ beliefs.

**School sample beliefs.**

In the questionnaire, the students were asked whether mathematics was an easy or difficult subject. The results appear in Table 8.1.
Table 8.1: Mathematics as a difficult subject

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>18.6</td>
</tr>
<tr>
<td>Agree</td>
<td>52.5</td>
</tr>
<tr>
<td>Disagree</td>
<td>24.0</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>4.9</td>
</tr>
</tbody>
</table>

The majority of students (71%) supported the statement that mathematics was a difficult subject, however over a quarter (28.9%) of the students did not. When posed with the question whether English was a difficult subject, the students’ responses were less polar. The results appear in Table 8.2.

Table 8.2: English as a difficult subject

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>9.7</td>
</tr>
<tr>
<td>Agree</td>
<td>46.4</td>
</tr>
<tr>
<td>Disagree</td>
<td>37.8</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>6.2</td>
</tr>
</tbody>
</table>

A slight majority of students (56%) supported this statement for English while 44% of students did not. Fewer students in the school population thought that English was difficult in comparison to mathematics. A paired samples t-test was conducted to investigate whether there was a statistically significant difference in the mean scores for student perception of difficulty for mathematics and English. The results of the t-test appear in Tables 8.3 and 8.4.
Table 8.3: Paired samples statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>2.85</td>
<td>485</td>
<td>.77</td>
<td>.03</td>
</tr>
<tr>
<td>15. Maths is a difficult subject</td>
<td>2.60</td>
<td>485</td>
<td>.75</td>
<td>.03</td>
</tr>
<tr>
<td>28. English is a difficult subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.4: Paired samples test

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 1</td>
<td>.25</td>
<td>.99</td>
<td>.04</td>
<td>.17</td>
<td>.34</td>
<td>5.65</td>
<td>484</td>
</tr>
<tr>
<td>Q15. Maths is a difficult subject – Q28. English is a difficult subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of the paired t-test indicated there was a statistically significant difference in the responses for Q15 Mathematics (M=2.85, SD = .77) compared to Q28 English (M= 2.60, SD = .03), t (484) = 5.66, p< .00 (two-tailed). The mean decrease for the pair was .25 with a 95% confidence interval ranging from .17 to .34. The eta squared statistic (.06) indicated a moderate effect size.

In the sample it was significant that fewer students identified English as a difficult subject compared to mathematics. The results indicate that the majority of students have the belief that mathematics was a difficult subject and this may be an influencing factor when students make decisions for selecting a non-compulsory mathematics courses in Years 11 and 12.
The relationship between mindset scales and mathematics as a difficult subject.

Pearson correlational analyses were undertaken to examine the strength and direction of the relationship between Question 15 on the questionnaire – Mathematics is a difficult subject with mathematics growth mindset, general growth mindset and English growth mindset. These results appear in Table 8.5. With the exception of the English growth mindset scale, the correlations were significant at 0.05 level (2-tailed).

Table 8.5: Correlation of mindset scales with question 15 (mathematics is a difficult subject)

<table>
<thead>
<tr>
<th>Mindset scales</th>
<th>Pearson’s correlation coefficient</th>
<th>Significance 2-tailed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics growth</td>
<td>-.32</td>
<td>.00</td>
</tr>
<tr>
<td>General growth</td>
<td>-.16</td>
<td>.00</td>
</tr>
<tr>
<td>English growth</td>
<td>-.08</td>
<td>.06</td>
</tr>
</tbody>
</table>

As illustrated in Table 8.5 there was a medium, negative significant relationship between mathematics growth mindset and question 15; mathematics is a difficult subject. The coefficient of determination was .10 (.32 x .32). Mathematics growth mindset helped to explain 10% of the variance in respondents’ scores on mathematics as a difficult subject. It is suggested the relationship might be expected to be negative, as a higher mathematics growth mindset would mean a perception of less difficulty with mathematics, or perhaps viewing the subject as more challenging rather than difficult.

As illustrated in Table 8.5 there was a small, negative significant relationship between general growth mindset and question 15; mathematics is a difficult subject. The coefficient of determination was .03 (.16 x .16). General growth mindset helped to explain 3% only of the variance in respondents’ scores on mathematics as a difficult subject. It might be expected that the higher the general growth mindset the less the perceived difficulty with mathematics. The relationship between mathematics as a difficult subject and general growth mindset was not as strong as the relationship between mathematics as a difficult subject and mathematics growth mindset.
As illustrated in Table 8.5, there was no significant relationship between students’ perception of mathematics as a difficult subject and their English growth mindset, indicating that the scale and the score were measuring different beliefs.

**The relationship between mindset scales and English as a difficult subject.**

Pearson correlational analyses were undertaken to examine the strength and direction of the relationship between Question 28 on the questionnaire - English as a difficult subject with mathematics growth mindset, general growth mindset and English growth mindset. The results appear in Tables 8.6. The correlations are significant at the 0.05 level (2-tailed).

**Table 8.6: Correlation of mindset scales with question 28 (English is a difficult subject)**

<table>
<thead>
<tr>
<th>Mindset scales</th>
<th>Pearson’s correlation coefficient</th>
<th>Significance 2 - tailed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics growth</td>
<td>-.10</td>
<td>.03</td>
</tr>
<tr>
<td>General growth</td>
<td>-.15</td>
<td>.00</td>
</tr>
<tr>
<td>English growth</td>
<td>-.33</td>
<td>.00</td>
</tr>
</tbody>
</table>

As indicated in Table 8.6 there was a small, negative significant relationship between mathematics growth mindset and English as a difficult subject. The coefficient of determination was .01 (.1 x .1). Mathematics growth mindset helped to explain only 1% of the variance in respondents’ scores on English as a difficult subject. It is suggested that students with a higher mathematics growth mindset might also have the perception that English is not a difficult subject. This result may indicate that students with a growth mindset regardless of the subject domain place some emphasis on learning or mastery goals.

There was a small, negative significant relationship between general growth mindset and English as a difficult subject. The coefficient of determination was .02 (.15 x .15). General growth mindset helped to explain 2% of the variance in respondents’ scores on English is a difficult subject. It is suggested that students with a higher general growth mindset might have the perception that English is not a difficult subject.
There was a medium, negative significant relationship between English growth mindset and English as a difficult subject. The coefficient of determination was .11 (.33 x .33). English growth mindset helped to explain 11% of the variance in respondents’ scores on English as a difficult subject. As might be expected students who have a higher English growth mindset might have the perception that English is not a difficult subject. It would also be expected that English growth mindset and English as a difficult subject would have a stronger relationship than mathematics growth mindset and general growth mindset with English difficulty.

**The perception of mathematics as an easy or difficult subject – interviewed students.**

To support the questionnaire data the results of the interview data analysis follow. This section illustrated students’ perceptions of the ease or difficulty of mathematics as a subject. The results appear in Table 8.7.

**Table 8.7: Perception of mathematics as a subject**

<table>
<thead>
<tr>
<th>Mathematics is easy</th>
<th>Mathematics is hard/difficult</th>
<th>Mathematics is in-between (medium difficulty)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 7 (16%)</td>
<td>n = 18 (40%)</td>
<td>n = 20 (44%)</td>
</tr>
</tbody>
</table>

The majority of students perceived mathematics as a difficult subject which varied in difficulty according to the topic. Different topics evoked different ability beliefs and effort requirements as described by the following students:

For me it sort of has its moments of being difficult and then being easy. Again it depends on the topic, it depends on all the little variables. (Lavinia8)

I don’t really like working with money such as tax and all that. I’m not good at that. I prefer algebra and topics that you need to figure out a lot more. (Monica9)

Two students pointed out that mathematics could be easy or difficult depending on whether you had natural ability in the subject as in Barbara’s comment:
I think it’s because everybody has, I suppose a different level of intelligence towards that topic and people understand it differently to another person. (Barbara10)

Furthermore, students pointed to mathematics as a difficult subject based on whether they were prepared to work at mathematics. Lavinia’s comment illustrates this as follows:

Maybe just your determination to actually maybe improve or to get this, so if you’re not trying then you won’t listen and then it’ll be more difficult. (Lavinia8)

A topic was considered more difficult if it was challenging and harder to understand. Wendy a student in Year 11 emphasised the need to really understand what was going on. She stated:

Sometimes it’s easy, and then when you don’t understand it is difficult. So I’d say it’s in the middle. Because obviously some topics are hard, some are easy, but when you understand it does become easy. (Wendy11)

Several students argued that your previous learning made a difference as to whether a topic in mathematics was easy or difficult. Karen stated:

Well some topics in the subject are harder than others because some we’ve done in previous years, not as in depth but we’ve still done the basis of it. And it’s also this year in Maths we’ve started trigonometry and I’ve never done that before, and that was more difficult than say algebra as we’ve done it in previous years. (Karen9)

The students (40%) who thought that mathematics was difficult based their arguments on the need to understand mathematics. They stated:

I think it’s definitely a difficult subject. I think it’s just everything individually is pretty easy to understand but once you put it altogether as a broad unit then it gets kind of confusing about how everything fits together. And I think that’s what makes it hard for people to understand. (Carmen11)

I like it when I can understand it, and I can get an answer. (Kay11)
Mathematics was considered difficult due to its numerical nature that made it different to other subjects and was often more perplexing. The nature of mathematics was appreciated by students depending on the topic being studied. Problem solving was regarded as a challenge for some students and a threat for others. A right or wrong answer might reinforce failure or success. It was noted by some students that the emphasis in mathematics on ONE correct answer was found by them to be ‘scary’ and anxiety provoking. Even when marks were awarded to the working out of an answer, it was not necessarily seen as a positive step, particularly if working couldn’t be shown. A comparison was made to the humanities subjects in which an extensive response was not marked wrong or right, but rather marks were allocated based on the quality of the response. In these subjects, the students did not feel their intelligence was being called into question “as everybody can write words” and it was always possible to be awarded some marks. Because mathematics had rules which had to be followed, it was seen by one student to be restrictive. Several students commented on the **specific nature of mathematics** which highlighted these views:

I think it’s just that different, it’s a very straightforward subject. There’s no airy sort of things. It’s just straightforward. You’re either right or wrong. It’s very definite. And you can correct yourself easily. It’s a different way of learning for me. It’s a different style. I’m more of an English person, but I think with numbers and that, it’s so different, that makes it difficult. (Eileen10)

I think that a lot of people find it harder because it’s that problem solving, use of numbers, and a lot of people, they may not be good at that, even though they’re first in English, Maths just isn’t their strong point. And I think, because it’s such a different subject to all the others that’s why it’s very different and difficult. (Bronwyn10)

It’s all difficult concepts and then they expect you to follow the rules and everything when it’s actually easier the way that you do it. (Stephanie9)
There were several students who found mathematics difficult but enjoyed the challenge of it. Their comments epitomise the characteristics of students with a growth mindset in mathematics. They stated:

It’s not difficult in a bad way. It’s like difficult as in it should, it challenges you but it should challenge you. It, like it is going to help you in later things. (Rebecca8)

It’s challenging, and I love to be challenged, so I can improve and get better and better. (Eliza8)

Only a small number of students suggested that mathematics was easy. The students who found mathematics easy liked its logic and definite nature. This was typified by the following responses:

I think because it’s very straightforward, this is what you’re doing. There’s no marks for the way you express something, it’s just this is right or it’s wrong. I find that easier because you know I have got the answer or I haven’t. (Cassandra11)

The logic. Like it is logical, so it’s not all over the place. You can follow it in steps and that is helpful. (Alice11)

Students who thought they had natural ability in mathematics often regarded mathematics as being easy. They described it as follows:

I kind of interpret, like I do it really well ‘cause I get it from my dad but it kind of just comes naturally I guess for me but, difficult? There’s nothing really difficult about it. Really, but learning a new topic and like getting into the gist of it and then once you get into it you kind of just flow along with it. (Candice10)

It comes naturally to me, so I get it easily. (Madison10)
Quite often the students who found mathematics easy also gave reasons why the remainder of the cohort found the subject difficult. They spoke as if they were a ‘bit different’ and not like the majority. They voiced their opinions in the following manner:

For me personally I find it closer to the easier side. I think that’s another reason why people don’t like maths a lot, because it’s quite easy to make mistakes and just like a small mistake can lead to a completely different answer. (Morwenna11)

For me personally I find it’s a little bit easier because I enjoy it, so it’s not a burden for me. Other students in my group feel like it is harder because it is all the same, all very much test, test, whereas other subjects you, might do assignments, media ... (Lavinia8).

Again putting time and effort into the subject were seen as critical in making mathematics easier. This was recognised by Patricia and Elizabeth. They stated:

I think it depends if you put more time and more effort and really try and understand what’s going on. (Patricia9)

I’m learning to get the hang of it and find different ways on how to work with it. (Elizabeth10)

The second theme relates to gender stereotypes and subjects.

**Gender Stereotypes Associated with Mathematics and English**

In this section appear the findings from the:

- school sample – gender scale; and
- students’ interviewed – perceptions of the gender stereotype associated with mathematics.

Each of these will now be reported.
School sample.

Two questions formed the gender stereotype scale. The summary statistics appear in Table 8.8.

Table 8.8: Summary statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender stereotypes</td>
<td>479</td>
<td>6.00</td>
<td>2.00</td>
<td>8.00</td>
<td>3.89</td>
<td>1.30</td>
<td>1.70</td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td>479</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was considerable variation in the sample in regard to gender stereotype. Five students (1%) scored the maximum eight (agreeing with the stereotypes) and 87 students (18.2%) the minimum score of two (disagreeing with the stereotypes). Seventy three per cent of students scored four or less indicating disagreement with the statements and 11.5% students scored six or above indicating support of the statements. The analysis of students’ responses to the questionnaire items for gender stereotype indicated a mean of four. It is suggested that the students in general did not support the stereotypes that girls are better in English than boys and that boys are better in mathematics than girls. However there was some acceptance of the stereotypes as just over 10% of students were in agreement with the statements. This agreement is a matter of some concern as the acceptance of the stereotypes may influence student implicit beliefs about their mathematical intelligence.

Pearson’s correlational analyses were undertaken to examine the strength and direction of the relationship between the gender scale with general growth mindset, mathematics growth mindset and English growth mindset. The results appear in Table 8.9. The correlations were significant at the .01 level (2-tailed).
Table 8.9: Correlation of mindset scales with gender stereotype scale

<table>
<thead>
<tr>
<th>Mindset scales</th>
<th>Pearson’s correlation coefficient</th>
<th>Significance (2 – tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General growth</td>
<td>-.21</td>
<td>.00</td>
</tr>
<tr>
<td>Mathematics growth</td>
<td>-.26</td>
<td>.00</td>
</tr>
<tr>
<td>English growth</td>
<td>-.23</td>
<td>.00</td>
</tr>
</tbody>
</table>

As illustrated in Table 8.9 there was a small, negative significant relationship between general growth mindset and gender stereotypes. The coefficient of determination was .04 (.21 x .21). General growth mindset helped to explain 4% of the variance in respondents’ scores on the gender stereotypes scale. It is suggested that students with a higher general growth mindset have perceptions that are less gender stereotyped.

There was a small, negative significant relationship between mathematics growth mindset and gender stereotypes. The coefficient of determination was .07 (.26 x .26). Mathematics growth mindset helped to explain 7% of the variance in respondents’ scores on the gender stereotypes scale. The r value was higher than in Table 8.8 indicating a slightly stronger relationship. It is suggested that students with a higher mathematics growth mindset have perceptions that are less gender stereotyped.

There was a small, negative significant relationship between English growth mindset and gender stereotypes. The coefficient of determination was .05 (.23 x .23). English growth mindset helped to explain 5% only of the variance in respondents’ scores on the gender stereotypes scale. It is suggested that students with a higher English growth mindset have perceptions that are less gender stereotyped.

Having a growth mindset may ‘protect’ students from the influence of gender stereotypes. Students with a higher mathematics growth mindset may be even less susceptible to the influence of the gender stereotypes than students with a higher general growth mindset or English growth mindset.
Perception of gender stereotype associated with mathematics – interviewed students.

Interview analysis revealed that 42 students (93%) rejected the stereotype that boys have more natural ability in mathematics while two students agreed with the stereotype. One student argued for female superiority in mathematics, however, her answer was based on effort not natural ability. Siobhan, a Year 10 student pointed out that “if the boys put in as much effort as the girls then they would probably be equally as good at mathematics as girls”. She thought that boys did not focus in school as well as girls and some boys didn’t bother putting the effort in. The two students who initially agreed that boys had more natural ability as they had heard the stereotype in conversation, changed their position after talking it through. Marlene gave credence to the gender stereotype that boys are better at mathematics by expressing her viewpoint in the following manner:

Maybe it has something to do with our gender and the way, maybe traditionally, you know, men were with Maths and learning about engineering and making planes, while women were at home washing. (Marlene8)

Further into the interview she contradicted this by adding that it was not gender, it was hereditary. Marlene placed strong emphasis on innate abilities throughout the interview.

Obviously there are some boys better at Maths than some girls and some girls are better at Maths than some boys, and it’s very – I think it’s up to your genetics really. (Marlene8)

Bronwyn and Anastasia who rejected the stereotype put it quite succinctly:

With intelligence we are all equal. Both boys and girls have intelligence to be able to go and learn about it. (Bronwyn10)

There may be differences in behaviour on how males and females act, but when it come to things with school, we all learn the same way. So it’s really an equal chance. (Anastasia8)
Whereas Elizabeth agreed with the stereotype. In primary school she had noticed that:

Boys had the answer first, always knew how to do it before the girls. They didn’t need an explanation that went into depth. Girls had to listen to the explanation and then figure it out. (Elizabeth10)

Although the majority of the interviewed students rejected the stereotype, it was concerning that most of the interviewed students have been exposed to the stereotype in some form or another. Subconsciously this exposure to the stereotype may impact on their mathematics mindset.

**Influences on Students’ Implicit Beliefs of Intelligence and Ability in Mathematics**

This section will be reported under the following themes:

- the peer pressure scale for the school sample;
- interviewed student beliefs about peer pressure and effort;
- interviewed students’ reports regarding teacher & school related factors; and
- interviewed students’ reports regarding parental & family influences.

The review of the literature revealed that peer pressure was an important factor influencing students’ mindsets. The findings from the questionnaire assisted in identifying the scale of:

**Peer pressure – school sample.**

Two items formed the Peer pressure scale. The summary statistics appear in Table 8.10.

**Table 8.10: Summary statistics for peer pressure scale.**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer pressure</td>
<td>487</td>
<td>6.00</td>
<td>2.00</td>
<td>8.00</td>
<td>3.41</td>
<td>1.20</td>
<td>1.44</td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td>487</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As illustrated in Table 8.10 there was considerable variation in the student population sample in response to peer pressure statements. One student (0.2%) achieved the maximum score of 8 which meant she strongly agreed with the statements of “in this school, students who try hard are teased” and “it’s not cool in my group of friends to try hard in class.” 144 students (29.6%) achieved the minimum score of 2 which meant they strongly disagreed with the statements. 83.6% students scored 4 or less indicating disagreement with the statements and 5.3% students scored 6 or more indicating support of the statements. The high percentage of students disagreeing with the peer pressure statements indicates that the majority do not think that students who try hard are teased and it’s not uncool to try hard in class. The mean for the student population sample was 3.4 indicating that students might feel that they could try hard in class and were not teased for working.

Pearson’s correlation coefficients were calculated to describe the strength and direction of the relationship between peer pressure and general growth mindset, mathematics growth mindset and English growth mindset. The results are recorded in Tables 8.11.

**Table 8.11: Correlation of mindset scales with peer pressure scale**

<table>
<thead>
<tr>
<th>Mindset scales</th>
<th>Pearson’s correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>General growth</td>
<td>-.31</td>
</tr>
<tr>
<td>Mathematics growth</td>
<td>-.32</td>
</tr>
<tr>
<td>English growth</td>
<td>-.35</td>
</tr>
</tbody>
</table>

As illustrated in Table 8.11 there was a medium, negative significant relationship between growth mindset and peer pressure. The coefficient of determination was .10. General growth mindset helped to explain 10% of the variance in respondents’ scores on the peer pressure scale. Students with a general growth mindset might have the perception of less peer pressure.

There was a medium, negative significant relationship between mathematics growth mindset and peer pressure. The value of r was slightly higher than for general growth mindset. The coefficient of determination was .10. Mathematics growth mindset helped to explain 10% of the
variance in respondent’s scores on the peer pressure scale. Students with a high mathematics growth mindset appear to be less influenced by peer pressure.

There was a medium, negative significant relationship between English growth mindset and peer pressure. The value of r was higher than for general growth mindset and mathematics growth mindset. The coefficient of determination was .12. English growth mindset helped to explain 12% of the variance in respondent’s scores on the peer pressure scale. Students with a high English growth mindset appear to be even less influenced by peer pressure.

The results indicate that a growth mindset may act as a ‘protective factor’ in buffering students from negative peer influences and particularly more so for domain specific growth mindsets such as English and mathematics.

**Peer pressure – interviewed students.**

Interview data analysis revealed that with one exception all students agreed that it was “OK” to work hard at school. Of these students, 19 (42%) explicitly mentioned that their peers support and encourage their work. This encouragement supports the quantitative findings from the school sample. Additionally the general growth and mathematics growth scales were also negative and moderately correlated with peer pressure. Students generally were not under pressure to have a poor work ethic. Some examples of comments which indicated peer support for effort were expressed by the following students:

- It’s everyone, they encourage each other. If someone’s having trouble with something, if they understand it they will help, or encourage them to go and get help for the problem. (Nancy8)

- It’s nothing to be ashamed of, I think working hard, because you should be proud of yourself, like, anyone should be proud of themselves for working hard and promoting education, like it’s never looked down on in my groups. (Ruth11)

- It’s just congratulations comments, like, there’s no jealousy going on. If someone gets a better result it’s OK. (Nerida11)
The common goal of “doing well” was a major driver for the peer groups. This was expressed by Marlene and Eliza:

I think it’s because we’re mature, maybe, because we understand that it is necessary. Like we will bag each other out, like, “you’re studying, you nerd,” but really we don’t mean it and we really do respect – we’ve got some smart people in the group – they’re going to do very well in life. (Marlene8)

I think we understand that one day we’re going to make it to the HSC and that helps to determine what we’ll do for our lives, so working hard to start with is going to help when we get into the older age groups. (Eliza8)

The students recognised the advantages of working together:

As we do, we just tend to complain about schoolwork and assignments a lot, but we all try hard to support each other. (Morwenna11)

All of us, if we have assignments or something, there’ll be a lot of us sitting there at lunch time, or recess, studying or doing assignments. We help each other out with stuff if we don’t get it. (Anastasia8)

The peer groups provided support in a range of ways by having common goals, engaging in friendly competition and motivating each other to persist. This was expressed by Eileen and Alice:

It’s a bit challenging. Everyone sort of plays off each other. Like, “I’m going to do this, better than you.” It’s a healthy challenge. If you have a test, you tell each other your marks. “Oh you just beat me by two marks”, or something. So that makes you go, “next time I’m going to probably put in that bit more”. And try and get better than them. (Eileen10)

We push each other to work hard and kind of motivate each other, and we also challenge each other so that we can all get to where we want to go next. It will help us out in the end. (Alice11)

Deborah in Year 11 sometimes found the competition to be too much:
I don’t really like to talk about it, because we’re so competitive. I want to do better than other students. (Deborah11)

The students were divided in opinion as to whether their peers valued or respected hard working students or those who were regarded as being smart. Fourteen students (31%) thought that the harder working students were respected more, while eleven students (24%) thought the smarter students were respected more. The majority of students (45%) argued that students who were smart or hardworking, or were both smart and hardworking, were respected.

According to many students, the respect for working hard was based on people’s admiration for those who tried and applied themselves to their work and achieved higher grades. Helen and Elizabeth highlighted this aspect in their responses:

Students who work hard, because at least they’re having a go and they’re doing the best they possibly can be. Well, as an example, in my Math’s class there’s this girl who always has tried everything, even if she gets an answer wrong the teacher will respect her and say, “At least you’re having a shot and I respect that”. And I just feel any student who has a go should be respected as they are taking a better shot. (Helen8)

If kids put work in and try and get exercises done and everything, teachers can see that they’re actually trying and they are giving it a go. So the teachers help you and I guess try and make that work easier for you to get. (Elizabeth10)

Patricia mentioned the comments made by some of her friends, indicating there was some peer pressure not to succeed.

I think students who work hard and get 95% in the test, that creates jealousy and people won’t socialize with that person or steer away from them because they might have the view of. “Oh, so and so is a nerd,” or whatever. (Patricia9)

Other students, regarded those who worked hard must also be smart as work ethic and intelligence were linked and impossible to separate. There was an acknowledgment that smart students work hard as mentioned by Kay and Susan:
I think they’re both respected equally. Most people who are smart put in a lot of the hard work, and that’s why they’re seen as smart I guess. (Kay11)

Usually the students that work hard are the smart students. Karina is my role model, she works really hard and she’s smart, well respected but humble about it. (Susan11)

Melanie pointed out that you can encourage people to be hard working but you cannot make them smart so the emphasis must be on the effort:

It’s probably best to be encouraged to be hard working, with like study seminars and things like that. So you can’t encourage people to be smart. (Melanie11)

Melanie did not recognise that people can get smarter, that is, their abilities can be developed. Her response implied a fixed amount of ability and only effort can be changed. She perceived that effort improved results and academic performance but intelligence was fixed.

Only one student thought that her peer group was agreeable to not working hard at school however Barbara’s comment implied that at times this was probably short-lived.

Some of my friends can be against that and they don’t put effort in, but when they see me or other people working hard I think that makes them realise, “Oh, that’s not such a bad thing.” (Barbara10)

Generally the girls’ peer groups were supportive of them working hard. School work was often the main point of discussion at recess and lunch. There was rivalry and usually healthy competition. Most students had HSC or career goals of doing well and consequently were achievement oriented.

**Interviewed students - teachers and school related factors.**

**Recognition and rewards.**

In general, students sought to be respected by their teachers and peers. The students who regarded smart students are being the most respected in the school emphasised that these students must have natural ability. Many students struggled with the concept of awards at school assemblies in terms of what the award was actually celebrating. Were the students getting first,
second or third place in each subject because they were smart, hard working or both? Most improved was due to hard work but the place getters were often regarded as ‘smart students’ not hard workers. Unless the student was known to them personally, for most students at the school assembly it was sometimes ambiguous whether these ‘smart’ students were hard workers or not. There was a sense that hard working students missed out. The students expressed this concern in their comments:

Probably those who are smart because they get acknowledged more, like as a dux. With the award ceremonies, like, “Oh she came first”, but not acknowledging those who are working hard enough. (Madison10)

Well just with assemblies and everything, it’s always with the people who come first and second, but then there’s not the prizes, for you can’t really do the ones that are most improved. (Lavinia8)

Natural ability was associated with being smart and the perception by some students was that the smart students get the higher awards or prizes and don’t have to work as hard. This was highlighted in the following students’ comments:

Some people it just comes to them naturally. There are girls who I know are really smart, they get distinctions in the competitions but they’re not paying attention in class, but they just happen to get full marks and stuff, so I guess that comes naturally. (Madison10)

I think students who are smarter, because they usually get the good marks which shows more that they understand rather than someone who is just hardworking but may not get as good a mark as the other person. (Sharon8)

Teachers were also thought to give smart students more attention and recognition. As suggested by Caroline and Wendy:

I think sometimes the teachers, if a student is really smart they may get along with them, like they talk to them a lot more. (Caroline9)
So the teachers sort of almost push them more to get better results, because they know they can. If they know they’ve got it in them I guess. (Wendy11)

Students who worked hard or were smart were given respect for different reasons. For Anastasia and Barbara, the school acknowledged both:

I think a bit of both really. If a student’s smart, they’ll get awards, everyone will know who they are. But if a student’s hard working, teachers will notice that and people in their class will notice. (Anastasia8)

I think the people who are hardworking are often looked at as wanting to get the mark that they get, and working hard to get that, whereas people who are smart, they’re respected for what they are and what they know. (Barbara10)

Several students realised that teachers varied in their encouragement of students. Sandra recognised this by adding:

I guess it depends on the teachers. I think overall, students who are smart are respected but then I guess with some teachers it is the hard working students. Like the students that put in the effort obviously are favoured and so they should be because they put in that effort. (Sandra11)

Deborah shared conflicting impressions of support by teachers:

There’s a lot of smart girls in my year. And so I feel that they’ve got like a lot of respect from the teachers because the teachers want their students to do well and they like it when their students do well. But I also think that the students who try and put a lot of effort in and ask questions in class, I feel that the teachers also respect those students as well because they’re showing that they’re putting an effort in. (Deborah11)

In the study of mathematics the students emphasised the relationship with their teacher and how the teacher made them feel in class contributed to their perceptions of ‘being able to do Maths’. As Helen and Cassandra explain:
Her positive comments she puts into me, so that makes me work harder, makes me feel like I’m a good student. Maybe the teacher’s input makes me feel like I’m going the best I can. (Helen8)

I like my teacher, I like my class, a really good group of people that motivates you and you just feel really happy when you walk into the classroom. So everyone’s excited to learn. (Cassandra11)

The students were reasonably assertive in their desire to understand mathematics, as well as their desire to achieve high grades. This assertiveness was demonstrated by not being a passive participant but seeking help in class by questioning the teacher and other students and taking opportunities for help offered by teachers before and after class.

I think in my Maths class especially it’s taken all of us a while to open up and I think once we’re all a bit more comfortable with each other we’re sort of more than happy to ask questions. But definitely in some other classes I’ve been in it’s like you can’t talk. (Bronwyn10).

Always asking your teacher whenever you can’t get an answer, and whenever I have a few questions that I can’t do, I always meet up with my teacher in the morning, like especially near exam time, and that’s how I get everything done, like I kind of understand everything now, and then I feel confident and that’s how I am good at Maths. (Ruth11)

Within the course of the interviews it became apparent the some students needed a private tutor in mathematics. Nine students (20%) were having personal tuition in mathematics outside of school hours and there was no mention of a tutor for their other subjects. The students explained their reasons as follows:

I have a private Maths tutor. She’s really good because she tailors her teaching and can explain something in different ways until I understand it. (Susan11)

Sometimes if I don’t understand I won’t put in the full amount of effort that I could and so I ask for help. I’ve had Maths tutoring outside of school. Sometimes I ask Mum and Dad or friends. (Caroline9)
Classroom environment.

Closely aligned with the important role of peer groups was students’ classroom environment. In general, students spoke of their classroom environment as supportive of learning. They recognised the teacher as having a key role in monitoring the classroom environment, stimulating and encouraging learning and developing personal relationships with students. Students acknowledged that teachers differed in their respect and attention to students, for example, how they praised and affirmed students who worked hard and/or had ability. Several students expressed that being smart was also associated with hard work and that working hard “made you smarter”. For some students advanced classes were viewed as being inhabited by naturally smart students rather than hard workers. This perception has implications for students who do not consider themselves to have ‘enough ability’ and that working hard may not result in promotion into the advanced classes. The grading or streaming of classes, which occurs most strictly in mathematics in the school, would not be an optimal environment for the development of a growth mindset.

Interviewed students - parents and families.

Students agreed that families played a major role in influencing and supporting their academic progress at school. Ellen and Rebecca shared their experiences:

Commitment, from parents. Their lifestyle, whether they get enough sleep. What the home situation is like, how much support they have. (Ellen8)

It’s kind of like what they do at home. I read a lot at home so I think that makes me better at English and people who do sports out of school, they’re probably better at sport and PDHPE. Parents who are scientists and mathematicians, their children would be better at these subjects because they could get help. (Rebecca8)
Influences on Students’ Mathematics Selection for Years 11 and 12

Interview data analysis revealed that 28 students (62%) recognised their parents being the main influence on their decision making for course selection, followed by their peers. Career choices and encouragement by teachers also played a prominent role in influencing their decision. Four students pointed out that no one would influence their decision and suggested that whether they selected to study mathematics in the senior years, would be their own decision. The major influences on decision making appear in Table 8.12 in descending order of frequency. In some instances, the students provided more than one example, resulting in the total number of examples exceeding the total number of students.

Table 8.12: Influences on students’ participation or non-participation in mathematics

<table>
<thead>
<tr>
<th>Influenced by</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents</td>
<td>28</td>
</tr>
<tr>
<td>Peers</td>
<td>15</td>
</tr>
<tr>
<td>Career choices</td>
<td>12</td>
</tr>
<tr>
<td>Teacher encouragement</td>
<td>12</td>
</tr>
<tr>
<td>Siblings/relatives</td>
<td>9</td>
</tr>
<tr>
<td>Like/enjoy Maths</td>
<td>8</td>
</tr>
<tr>
<td>A useful subject in life</td>
<td>7</td>
</tr>
<tr>
<td>Ability/Achievement</td>
<td>5</td>
</tr>
<tr>
<td>University courses (prerequisite)</td>
<td>3</td>
</tr>
</tbody>
</table>

It was noticeable that the parents’ culture had an impact on their daughter’s motivation to succeed. What was memorable from the interview were the students whose parents had been born in Fiji and Bangladesh and who gave emphatic support to the importance of mathematics in the senior years of schooling. Ruth and Madison shared their family backgrounds:

So as I say, my parents, it’s either taking science or maths or both, so I had to take maths. Because they’re from Fiji, they came here when they were my age, and because they never got the education, I always hear this, because they never got the education that we
have, they think that the most important subject are English, maths and science, so if we’re not doing any of them, because we have to do English anyway, but if we’re not doing maths and science and they’ll think that’s terrible, like they’ll think that it’s not challenging me. (Ruth11)

My Dad was born in a really small village in Bangladesh and the only way to make your way up was through Maths and school, and Maths was heavily emphasised there. And he’s being doing well, and them from that to the city and then here. I was born there as well. My parents want me to be a doctor. (Madison10)

Morwenna, was currently being accelerated in mathematics and would complete the Year 12 HSC course in Year 11. She possessed a strong work ethic and was academically highly motivated. Morwenna equated her success in mathematics with innate ability and working “smarter” which was particularly encouraged by her parents from Southern China. She shared her story:

I think it’s not about working harder but working smarter. It’s sort of finding the right way of studying for yourself. My parents have encouraged me to work hard in Maths ever since I was young. I’ve been going at it for a long time. I was sort of neutral towards Maths. I didn’t like or dislike it, it was just a subject that I did well in. So I think that was mainly what factored into me choosing Maths and I just kind of grew to enjoy it quite a bit. (Morwenna11)

Margaret’s parents were more laissez-faire and supported her decision not to select mathematics in the senior years:

I was very adamant that I’m not doing it. My mum said, she knows, she gets what I mean. Like she struggled with it as well. So she said if you don’t want to do it, don’t do it kind of thing. (Margaret10)

Four students did not completely accept the premise of being influenced by others. Kathleen shared her views:

Yes, just purely my decision whether to take maths or not. Because like it’s my life and my parents can make suggestions. But I’m the one who makes the final decision but I’m the
one who made that one. I might take maths, I think it’s just wait til the future and see what happens. (Kathleen9)

Parents’ experiences of mathematics and what they appreciated influenced their daughter as mentioned by Stephanie:

Just noting that my – because both my parents, they dropped maths in Year 10 and there are certain things that they find a bit difficult and they wish that they took it in Year 11 and 12. (Stephanie9)

The home environment and parental encouragement were vital in promoting their daughter’s interest in and desire to continue in mathematics as Candice and Bronwyn demonstrate:

I kind of interpret mathematics easily, because I get it from my Dad, he is a builder and was really good with Maths, always “uses his head and stuff” and it kind of comes naturally to me. Like I get it from my Dad but he was always around showing me things when I was young. I do wood technology and we go down to Mitre 10 together and he always tells me different ways to do everything. I wanted to do general this year because I wanted to learn the real world of Maths such as taxes and interest rates and then Mum said “no, you’re so much better than that, so aim higher”. So I chose Mathematics 2 unit not General Mathematics. (Candice10)

My parents have always been happy to help out with my Maths homework and they know tricks and stuff that they can help me with and which has aided me a lot over the years. (Bronwyn10)

Students were not specifically questioned as to the use or type of praise expressed by their parents in day to day conversations, however when the students provided an example of parental praise, its type was noted. Dweck (2009, p. 9), points out that when students are praised for the process they engage in, for example, their strategy, concentration or persistence then “this promotes a growth mindset with its emphasis on learning and its resilience”. Karen gave an
example of mainly process-focused praise outlining a growth approach used by her parents to encourage her efforts.

Well when you do well parent and friends do support you. They say “You did really well in that” and also if you don’t go as well they say “You’ve done what you can, so maybe you can try and see what you got wrong and try and learn from your mistakes”. (Karen9)

Like parents, the students’ siblings or close relatives exerted an influence on the decision to pursue mathematics as expressed by Eileen and Shiobhan:

My older brother, I suppose. Because he’s done Maths his whole life, he’s really good at Maths and he helps me out if Dad’s away, or something, if I have a Maths test coming up. Yeah, he’s real good at Maths, so that’s really good. I help him with English, I raised Year 12 text this year with him. We help each other out. (Eileen10)

Probably my Aunties and Uncles, my Aunty is only four years older than me so she probably influenced me. Yes, she went here, she probably influenced a little bit ‘cause she only took a General course. She said that’s helpful and she still uses it now so it’s good. (Shiobhan10)

Cassandra also mentioned her brothers and their experiences:

I think because maybe seeing older siblings or their experiences and comparing it to other people and you can see that they’ve worked hard and they’ve got all these opportunities now and that’s because they’ve worked hard at school. (Cassandra11)

For many students their friends played a crucial role in influencing their decision to continue with mathematics. Julie and Barbara explain:

Even my friends encouraged me to take Maths because it would just give me that balance and something else that I could be acknowledged by. I think it was, yeah, they definitely said, “look, you should probably take Maths. It’s probably going to be the best thing if you want to get into university. And even if you don’t get into university, you have something
else that you can be recognised by, and they felt that Maths was very important, And so did I; it wasn’t that I didn’t feel as though I wanted to do Maths. (Julie11)

I think my classmates and my teacher have helped because I know that when I walk in to that class next year I’ll be around supportive people and they won’t be trying to overrule each other and that, that you’ll be able to sit down and you can work it out together if you need to. (Barbara10)

Students reported that they requested their teachers’ validation of their ability. For example, “Do you think I am capable of achieving well in senior mathematics?” “Should I go on in Maths? “What level should I attempt?” Students doubted whether they had sufficient ability and confidence to progress further. Helen and Kay shared their insights:

The teachers, because just them making me feel good about myself and that I’m going great makes me feel like, yes, I should take Maths. (Helen8)

I guess if I was doing better in mathematics 2 unit I would have stayed in that class. My Maths teacher did say that “I should stay on because I think you’re going to do a lot better”. But I was just struggling too much. And inside I knew it was the best decision to go down to general Maths, and do something that I can understand. (Kay11)

Students’ previous experiences in the junior mathematics classroom and the teachers who would be allocated to senior mathematics classes played a crucial role in their decision to progress further in mathematics. Kathleen and Ruth relate their experiences:

Like it helps to have a good teacher that explains a lot and that would make me go there more but then if you have a teacher that says “here’s a worksheet, do that, it’s like no I’m good. (Kathleen9)

Year 7 to 10, I wasn’t good enough, I was really bad, but then ever since I got this certain teacher it’s worked. We get along really well, she’s humorous and makes it fun. So if you
have a teacher who makes the subject fun, and then you do really serious stuff, it kind of benefits you and being in the top class definitely benefits you. (Ruth11)

As would be expected, the emphasis on careers and future prospects featured more strongly in the senior students’ responses as expressed by Deborah:

Well, when I finish school I really want to join the Defence Force and hopefully become a pilot. I am in the Air Force cadets at present. And so maths, and physics and chemistry - that’s quite important for that job. And, yeah, I just think it’d be good to do. (Deborah11)

However, there were several younger students who had given the topic a great deal of thought such as in Anastasia’s case.

Just, I know that every job needs Math, at some stage. If you don’t take Math, then you can be stuck. Even just simple things like working in a retail store, you still need Math. No matter what I want to do with my future, if I have Math as something that I can do, then I’ll be able to really do a lot of things. (Anastasia8)

This last results chapter reported on student beliefs about the ease or difficulty of mathematics and the reasons for these beliefs. Students acknowledged an awareness of the gender stereotype that males are better at mathematics than females, however the majority of students were not in agreement with the stereotype. Students reported the influences of their families, peers, teachers and school related factors on their implicit beliefs of intelligence and ability in mathematics in particular, and how this affected their present and future participation in mathematics. The next chapter will be a discussion of these influences on students’ implicit beliefs of intelligence and the effect on mathematics participation.
Chapter Nine: Discussion

Students’ Perceptions of Factors Influencing Mindset

Data analysis of interview responses revealed that students were indeed influenced by sociocultural and environmental factors. These factors have an impact on the development and nurturing of implicit beliefs of intelligence particularly in relation to the study of mathematics. As Wang and Degol (2013) explain:

Individual motivational beliefs do not develop in a psychological vacuum; rather they develop under the influence of various ecological contexts, including family, peer groups, school, biology and society at large. Motivational beliefs are influenced by the rules and roles prescribed by these social contexts, many of which pertain to gender. (p. 310)

A discussion of these factors include the perception of the difficult nature of mathematics; the stereotype of mathematics as a masculine subject and the influence of peers, parents, teachers and schools on students’ ability and achievement.

The Difficult Nature of Mathematics

Bonne (2016) notes that in the western world, mathematics has traditionally been positioned as a difficult academic subject. Questionnaire and interview data analysis revealed that a minority of students regarded mathematics as an easy subject. The majority of interviewed students regarded mathematics as being difficult or between easy and difficult depending on the topic. The subject was not viewed as a whole but rather comprising many parts or topics for example, arithmetic, algebra, trigonometry, calculus. Different topics could evoke different ability beliefs and effort requirements. Foushee et al. (2017) regard this broad conception of mathematics expressed by students “as a protective factor against the propagation of mathematics anxiety and avoidance” (p. 2019). Rather than labelling all mathematics topics as “Maths” students recognise difficulty and ease with individual topics. Students have substantially different ideas of what constitutes mathematics and the greater the “breadth” of their maths conception the less likely they will be to experience mathematics anxiety (Foushee et al., 2017, p. 2024). The less
anxiety a student experiences in a subject, the more likely they will be to enjoy the subject, expend more effort and improve achievement.

Generally the findings of this study align with the literature that the study of mathematics has been perceived as inherently difficult and demanding. As reported in Chapter Six, two students who were high mathematics achievers did comment that they ‘might be different’ to other students and both these students emphasised innate mathematical ability and effort in developing their abilities. None of the interviewed students, however, regarded girls who were very good at mathematics as eccentric, nerdy or ‘bizarre’ (Nardi & Steward, 2003, p. 359). In an all-female class, Steele et al. (2008), argues that students become acculturated to mathematics and feel like insiders. Females are not oppressed by gender roles and expectations and they relax and learn.

Interviewed students reported that mathematics was different to their other subjects as it had many rules and procedures. It was logical, straightforward and numerical with right and wrong answers. Boaler (2016) points out that students regard mathematics in this way because this is how they are taught. She explains that the difference in mathematics compared to other subjects is not because of the nature of the subject but because of the widespread misconceptions held by parents, teachers and students of the nature of mathematics. Custom and practice in the way mathematics has been taught, perhaps as a set of procedures and rules, may have led to unpleasant experiences and memories. Boaler aspires that mathematics be seen as a creative, visual, connected, living subject and taught and experienced with this in mind. Boaler (2016) states:

It is very hard for students to develop a growth mindset if they only ever answer questions that they get either right or wrong. Such questions themselves transmit fixed mindset messages about mathematics. When we teach mathematics - real mathematics, a subject of depth and connections - the opportunities for a growth mindset increase, the opportunities for learning increase, and classrooms become engaged with happy, excited, and engaged students. (p. 32)
Stereotype of Mathematics as a Masculine Subject

Data analysis of the questionnaire results and interviews revealed that the majority of students rejected the stereotype that mathematics was a ‘masculine subject’. However it was apparent in the interviews that the students had been exposed to the stereotype possibly in family conversations, with social acquaintances or media publications. Gendered notions of masculine mathematical brilliance will affect future female interest and career aspirations.

Bian et al. (2017) point out that this “brilliance = males” stereotype has been used in the past to explain the gender gaps in many prestigious occupations (p. 1). Meyer et al. (2015) argue that women are under-represented in fields that emphasise the need for raw ability rather than effort as women are influenced by the cultural stereotyping of gender and ability such that men are more likely than women to possess raw ability. The all-girls’ school with mainly female teachers may protect the students somewhat from any gender discrimination in the normal school day. Eisenkopf et al. (2015) reported that single sex schools improve girls’ mathematics achievement and engender less stereotype threat in mathematics. Females have been found to be stronger than males in the belief that mathematics is gender-neutral (Kloosterman et al., 2008). The students tended to reject the notion that gender would impact on their academic outcomes yet our broader discussions reflected some stereotypical constructions of gender. This finding is supported by the work of Francis et al. (2014) in their study of gender in undergraduate accounts of university experience described this paradox.

Students tended to reject the notion of gender and/or other social variables impacting on behaviours and outcomes in their undergraduate experience. However, as we might expect, gender did emerge in their accounts; sometimes in relation to direct questions and sometimes serendipitously in their discussion of student life. (p. 6)

Nosek et al. (2002) remind us that we need not endorse gender stereotypes consciously for these stereotypes to have a mental existence and to influence behaviour. They state:

The human ability to explicitly reject beliefs that are not considered just or fair may then provide false assurance that stereotypes do not play a role in the formation of
preferences that are thought to be of one’s independent choosing. Knowledge of stereotypes, even implicit knowledge, may be sufficient to perpetuate stereotypes and even discourage women’s subsequent participation and performance in math domains. (p. 57)

Brandell and Staberg (2008) also found that students had strong notions of gender differences, but denied them when explicitly asked. Beliefs about ability according to Huguet and Régner (2009), do not appear to moderate susceptibility to stereotype threat, as it has been shown to operate amongst middle school girls who deny negative stereotypes about girls and mathematics. The researchers argue that female students’ counter-stereotypic beliefs cannot be taken as sufficient evidence for the decision by teachers to intervene or not intervene in the struggle against stereotype threat.

Two Asian-Australian students in my study emphasised their mathematical ability as a reason for their high achievement in mathematics. They may have benefited from the positive stereotype that portray them as “model minorities” who are destined to succeed (Hsin & Xie, 2014, p. 8420).

Of concern is the finding that 13% of the student sample agreed that males have more natural ability in mathematics. The perception of mathematics and gender continues to be an issue for high school students. Although most students were generally emphatic about mathematics being a gender neutral subject, their interview responses indicated societal expectations of males being more successful in the STEM subjects. Nardi and Steward (2003) in the context of their study report an “overwhelmingly high number of almost exclusively female students who express rather fatalistic views on the innateness of mathematics ability” (p. 358). The belief that males have more natural ability in mathematics may lead to more fixed mathematics mindsets for females as they may regard themselves as lacking mathematical ability and subsequently no amount of effort would result in success. Student training in the development of a growth mindset will reduce or nullify the effects of the gendered mathematical stereotype. Teachers could actively address the masculine gender bias in mathematics classes and discuss the implications of future STEM participation for female students. However, the gendered stereotype of mathematics issue is not solely the responsibility of teachers.
Davis (2017) reports in The Guardian the quote by Dame Donald, professor of experimental physics at the University of Cambridge:

> If we are to facilitate a gender-balanced workforce of engineers, mathematicians and physicists in the future it is clear interventions at secondary school just aren’t going to be sufficient. Parents, teachers and the media need to work much harder eradicating gender stereotypes in the way they talk about adults to children of all ages. (p. 3)

In an all-girls’ school, students are possibly more exposed to feminism and the endorsement of gender equality. Leaper et al. (2012) argue that girls are more likely to have stronger mathematics and science motivation if they endorse gender equality. The finding reported in Chapter Six that 77% of the student population have selected or are intending to select a non-compulsory mathematics course for Years 11 and 12 may be due to the empowerment of girls in an all-female school.

**Peer Groups**

There are many challenges associated with being a young woman in high school. Romero et al. (2014) note the changing of classes for each subject, numerous teachers, higher teacher and parental expectations, grading standards and more difficult work as potential challenges. Overall there is more pressure to achieve and be successful. At the same time the students are progressing through the stages of adolescence with its inevitable changing peer relationships (Wang & Eccles, 2012).

School and classrooms are inherently social places and the peer group can have a significant influence on adolescent achievements, beliefs and behaviours (Ryan, 2000). Lee (2002) describes how peers play pivotal roles of “competitor, supporter, motivator and role model in adolescents’ talent development” (p. 26). Interview data analysis revealed examples of how students’ peers played these four pivotal roles in the mathematics classroom. The students particularly emphasised the support and encouragement of their peers. Wang and Eccles (2012) note that girls tend to seek social support as a coping strategy whereas boys tend to use avoidance as a
coping strategy. Certainly as the students progressed further into higher level mathematics courses such as Extension 2 in Year 12, they expressed the need to have their friends in the class.

Sullivan et al. (2006) argue that classroom culture may be a much stronger determinant of engagement than the curriculum, pedagogy or teacher experience. Overall the data analysis revealed positive peer responses to school mathematics opportunities and the students were not inhibited by a combination of possible indirect pressure from peers not to apply effort in school. Classroom culture descriptions did indeed feature strongly in their interview responses. Steele et al. (2008) propose that single sex classes solve the problem of classroom inequity because they remove females from settings “in which they compete unsuccessfully for attention” (p. 11). Interview data analysis revealed that the students enjoyed the all-female environment with its emphasis on work completion and doing your best. There was little tolerance of students distracting others from learning.

**Teachers and Schools**

All mathematics teachers in the school were women; a context which provided role models and witnesses to the importance of mathematics for females. Students reported in the interview how their mathematics achievement had improved based on the particular teacher for the year. Quality teaching for the students meant that the teacher was knowledgeable and presented work in an interesting way, had a sense of humour, made mathematics fun, enabled the student to “feel good about herself in that she could do mathematics” and used worksheets and textbooks minimally. Gregory and Weinstein (2004) note that growth in mathematics achievement is greater for those students who feel that their teachers offer praise, listen well and show an interest in students.

According to King et al. (2012) how students think about their intelligence is associated with how they feel about school. It was noted in the interview profiles that students with mixed or fixed beliefs of intelligence in mathematics and did not wish to select mathematics at the senior level, expressed more negative sentiments of the subject, such that it was boring, repetitive and meaningless. Their responses were varied with elements of sadness, regret and some anger particularly about how mathematics was taught and conducted in the school. King (2017) argues
that a fixed mindset leads to negative affect such that students’ implicit beliefs of intelligence may also have a key influence on subjective well-being. In contrast to these negative attitudes expressed by some students, other students had a growth mindset and expressed positive activating emotions of enjoyment, fun and pride in their work in mathematics. King (2017) suggests that implicit theories of intelligence and well-being “reciprocally influence each other across time, both operate simultaneously and are likely to be closely intertwined” (p. 138).

Contextual factors have an influence on achievement beliefs and behaviours (Schunk & Meece, 1992), and these factors are often downplayed in hypothetical scenarios or research conducted outside classrooms. Schools are an important context in their own right. Eccles and Roeser, (2011) validate schools as a context for study. It is suggested that education research needs more in-depth contextual information, particularly teacher and student data in relation to adolescent academic outcomes and academic mindset. Interview data analysis revealed the complexity of implicit beliefs with students simultaneously holding growth and fixed mindset beliefs. These mixed beliefs may arise due to teachers giving students explicit and repeated feedback indicating their progress in learning which may inculcate a growth view of ability. In contrast, the social and group nature of many classrooms or grading of classes may emphasise differences in student abilities, which may encourage fixed beliefs. The student receives mixed or conflicting messages about ability. As Schunk (1995) explains:

> Teachers often convey incremental information because they tell students they can improve with diligent effort, persistence, and careful attention to procedures, but social factors may convey entity information. (p. 313)

As students move through secondary school they are exposed to more performance oriented and ability focused classrooms. Interviewed students revealed that at the end of each topic, and particularly in mathematics, students’ knowledge and skills were assessed either by a test or an assignment. Students who already have a fixed mindset are more likely to adopt an ability focused orientation to learning. This orientation may not cause them any problems if they are achieving well however if they are not, such a mindset is likely to undermine their engagement in learning. If teachers have a fixed mindset, they would also be more likely to use ability focused
pedagogical strategies. Developing a growth mindset for all students would require teaching strategies linked to a mastery rather than an ability orientation however for this to be successful all teachers would need to have a growth mindset. Teacher’s own implicit beliefs about intelligence have a very powerful role to play in student achievement however teacher mindsets were outside the scope of this research study. Meece et al. (2005) warn that:

School environments that are focused on demonstrating high ability and competing for grades can increase the academic performance of some students, however research suggests that many young people experience diminished motivation under these conditions. (p. 487)

Martin (2015b) argues that many students may not outperform their peers but they can outperform their previous effort. The challenge for educators is to understand more about the contexts that foster beliefs in malleable intelligence and produce goals that create growth in intelligence.

**Grading of classes.**

In this research study, mathematics was the only subject in the school in which students were strictly streamed or graded based on the results of mathematics assessment tasks. From Years Seven to Ten, classes in each year cohort ranged from the two top classes which were graded, with one higher than the other, to three mixed ability and one remedial or special needs class. The philosophy underlining this faculty decision was to promote extension and acceleration of the more able students and give more assistance to those students who needed it by grouping them homogenously. Competition was encouraged and students could be moved between the top and the mixed ability classes after assessments, usually at the end of term, resulting in a different teacher and peer group. Although once students had been assigned to different course levels based on assessment grades, movement to another course seemed to be infrequent. Very capable mathematics students agreed they worked very hard to stay in these two top classes. Attard (2013) found that while students placed in higher ability groups perceive themselves as “doing well” in mathematics, such grouping also “places pressure on high achieving students whilst limiting the potential of attainment for students in lower ability groups” (p. 572).
Middleton et al. (2004) explain that there is instability when students move from one learning environment to another, one class to another, such that “as contexts change, individuals reevaluate and reconstruct their goals and actions” (p. 293). This movement between classes could also have an undesirable effect of enforcing fixed beliefs in mathematics, particularly for a student who worked hard and had not been promoted into one of the top classes. One student cited the grading of classes as the reason for her “disenchantment with mathematics” coming to believe that she did not have the required ability to be in these classes. Teachers who gave tasks in which greater effort paid off with improving grades may foster growth intelligence beliefs however those teachers who emphasised competition where ability equated with performance may cultivate fixed beliefs. Research by Boaler (1997b, 2013), showed that ability based groupings encouraged fixed mindset thinking. Mathematics classes based on ability groupings in this study may account for the weaker growth mindset in mathematics compared to English and general growth mindset.

There was no evidence raised during the course of the interviews of teachers comforting students with “it’s OK not everyone can be good at math” (Cooper, 2012; Rattan et al., 2012). Instead, several teachers seemed to be actively encouraging students to select the more challenging mathematics 2 unit and extension courses rather than general mathematics. The weaker growth mindset for mathematics compared to English and general growth mindset reflects the lack of conviction the students have in developing their ability to study more advanced mathematics.

It became apparent from the student conversations just how crucial the teacher’s role was in fostering and aiding the growth mindset. Rosenholtz and Simpson (1984) found that teachers were both more and less powerful in helping students to develop their ability.

They are more powerful because by altering the structure of their classrooms they may be able to change some aspects of children’s socialisation currently thought to be produced by inevitable development. They are less powerful because teachers’ own personal philosophies and intentions tend to be overridden by the effects of the performance structure of their own classrooms and by the peer comparison processes set in motion by that structure. (p. 55)
It is of considerable importance that teachers are professionally developed in cultivating student growth mindsets and to also be mindful of their own implicit beliefs of intelligence and how these beliefs can be expressed and put into practice.

Parents and Families

Student interview responses highlighted parental influences on their beliefs and values. Students reflect some of this parental influence by quoting their parents advice; “mathematics is important in terms of education and future employment”. Students who thought that mathematics was a relevant subject usually gave examples of their parents’ use of mathematics in hobbies or in their workplace. Leaper et al. (2012) reported evidence of girls’ science and mathematics motivation being positively associated with their mothers’ mathematics and science support. Several students acknowledged that it was their mother who had encouraged them to volunteer in the study and who urged them to take on the higher level mathematics. As a positive role model for interest and/or participation in mathematics related careers, the mother would be a powerful force in influencing female motivation in STEM courses.

Herbert and Stipek (2005) had reported that parents have been shown to rate girls’ and boys’ abilities differently according to gender stereotypic beliefs. Parents may underestimate girls’ performance and overestimate boys’ performance in mathematics. There was very little evidence of parent gender stereotypic beliefs mentioned in the student interviews. However, students did proclaim that parents emphasised “working hard resulted in success in mathematics”. This relationship has been associated more with female achievement rather than natural ability. Overall there was significant encouragement by parents for their daughters to continue with mathematics at the senior level however not necessarily at the higher advanced level.

The students gave very few examples of parental praise, indicating perhaps that for adolescents, parental action and deeds were more important than words. Karen in Year Nine, however, gave an example of process praise such that she was praised for her efforts and perseverance. Her parents whether deliberately or subconsciously were developing her growth mindset with its emphasis on learning and resilience.
Culture

Intelligence cannot be fully or meaningfully understood outside of its cultural context (Sternberg & Grigorenko, 2004). There was a clear indication in the interviews that culture played a pivotal role in the high expectations expressed by some parents of their daughters’ achievement in mathematics. Students whose parents had been born in Asia, particularly China and India placed great emphasis on their daughter selecting a high level of mathematics and choosing a prestigious career normally associated with mathematics and science, such as medicine or engineering. Australian born parents, although encouraging of their daughters did not seem to place such emphasis on strictly STEM careers. There seemed to be a more laissez faire attitude by Australian born parents such that it would be ultimately their daughter’s decision to further her study in mathematics. Mathematics was encouraged but not necessarily at the higher levels nor was emphasis given to careers that were strongly associated with mathematics.

In many ways the Asian born parents had developed with their daughters a growth mindset; the belief that all children are capable of developing the ability to learn and learning is maximised by effort. Asian-Australian students who were interviewed also showed high academic motivation and this according to Jose and Bellamy (2012), may also be due in part to increased feeling of family obligations.

In summary, a students’ implicit beliefs of intelligence are formed and influenced by their culture, family upbringing and school related factors. As Wang and Degol (2016) point out, “these factors are more than the sum of their parts; they aggregate and interact over time” (p. 320). Teachers and parents have an important role to play in developing and maintaining a child’s growth mindset. The need for teacher understanding and sensitivity to students’ mindset should be valued and given priority. Chapter Ten concludes this study and addresses the big - picture issues and concerns.
Chapter Ten: Conclusion

Reviewing the Study

The study investigated the implicit beliefs of intelligence or mindset that female secondary students hold and in particular, the beliefs they hold about ability and effort and their impact on academic achievement. In addition, the relationship between these beliefs and students’ self-reported learning behaviours was investigated. Central to the study was how intelligence mindsets offer a valuable way of understanding students’ attitudes towards, and participation in mathematics. In addition, students’ perceptions of the factors influencing their implicit beliefs in general, and in the study of mathematics, were explored.

A pragmatic parallel mixed methods approach (Mertens, 2015), was selected to undertake the research. Multiple data sources were used to investigate mindset. The sources included student questionnaires and interviews with a sample of the surveyed students. The research was designed to include two relatively independent phases, quantitative followed by qualitative data collection and analysis. The inferences made on the basis of the results of each method were compiled to form meta-inferences and these were reported in the discussion chapters.

Major Conceptual Findings

Mirroring the majority of empirical studies on mindset, one bipolar construct of implicit beliefs was used, each for general growth, mathematics growth and English growth mindset, instead of two unipolar constructs for each implicit belief in the questionnaire. The entity scale measure for each implicit theory was reversed and combined with the incremental scale score to calculate a mean implicit theory score. In agreement with Lüftenegger and Chen (2017), I now challenge the traditional conceptualisation that incremental and entity theories appear to be each other’s opposites, as a large proportion of interviewed students described mixed beliefs of a growth and fixed mindset for mathematics. Schunk (1995) pointed out that people can access both beliefs depending on how the specific context makes one belief more salient than the other. Dweck et al. (1995) had recognised the possibility that people can hold both beliefs at the same time. Taking all this into account, particularly given the powerful student mixed mindset voice in this
study, I agree with Lüftenegger and Chen (2017) who suggest “a much looser coupling of entity and incremental theories and raise doubts about whether implicit theories should be treated as a single bipolar construct in empirical research” (p. 101) It would be of interest for future research to understand student’s orientation with regards to both factors. Martin et al. (2017) suggest that “this may allow for more differentiated and focused intervention by addressing fixed and growth beliefs as distinct factors” (p. 9).

The results of this study have shown that students’ implicit beliefs about intelligence are extremely important in how students perceive themselves as learners. The fixed mindset can undermine academic performance and interest in pursuing a particular career path (Aucock, Merino & Wilmot, 2017). Although the quantitative result for the school sample indicated a general growth mindset; interview results suggested a more complex mindset picture that included a mixed growth mindset.

Overlaying these mindsets were three other variations in student beliefs. Firstly, the very popular belief that intelligence was inherited (innate) and could be further developed by learning and life experiences. Secondly, the students who set a ceiling or cap on their intelligence by assuming they could only improve to a certain level, showed evidence of holding both a fixed and growth mindset. Lastly, students who held the belief in multiple intelligences as they perceived some dimensions of their intelligence were fixed, while other dimensions were malleable. In addition, students held the belief that improved school achievement was possible, however, this was not related to increased intelligence.

The results also revealed two major ways in which students viewed effort and its relationship with ability or intelligence. Firstly, effort was positively related to intelligence, in that hard work could result in students’ intelligence being developed. Secondly, effort was inversely related to intelligence, such that students with low ability or intelligence must work harder than students with high intelligence. This belief reflects a more fixed mindset. As students may move from growth to fixed beliefs and vice versa depending on the subject or context, their view of the role of effort in the subject may also vary.
The results of the study, revealed that the school mathematics growth mindset mean was significantly lower than the general growth mindset mean, indicating students had a more fixed mindset for mathematics. The lower mathematics growth mindset mean for the school sample reflected the students’ belief that success in mathematics was more contingent on ability, and their reservations regarding whether their ability could be developed. In addition, the students who selected a mathematics course for Years 11 and 12 had a higher mathematics growth mindset than students who did not wish to study mathematics at the senior level. This finding was extremely important as it revealed that participation in mathematics was significantly related to a growth mindset. This finding raises important implications for educators.

Romero et al. (2014) had also found that middle school students with growth mindsets were more likely to select more advanced mathematics courses in the future. A more fixed mindset for mathematics underpins the lack of student participation in the more advanced senior mathematics courses and the consequent lower participation in STEM subjects at the tertiary level. Motivation to study mathematics is influenced by mindset as it impacts on the extent to which students perceive their mathematical abilities as malleable as a result of experience and practice.

Some students acknowledged, but failed to agree that their mindset was influenced by the stereotype that mathematics was considered more of a masculine subject. The students recognised that they were conscientious and hard workers: qualities compensating for perceived natural mathematical male ability.

The societal perception that mathematics was considered a difficult subject also made a distinct impression on students. Students voiced their concerns about whether their level of intelligence was sufficient to successfully study mathematics.

Further results indicated that Asian parents influenced and encouraged their daughters to study mathematics at the highest level, and undertake a prestigious career. The students with Asian parents, had high goal orientation, both mastery and performance goals with a strong belief in the role of effort.
Mindsets are formed and influenced over time so it is imperative to understand the factors influencing students’ conceptions of intelligence. Additional research is needed to understand the contexts that foster beliefs and growth goals. This understanding of contexts is critical for teachers and researchers designing learning environments where the efficacy of effort beliefs and emphasis on ability growth can be fostered. Mourshed, Krawitz and Dorn (2017) conclude that “after controlling for other factors, student mindsets are twice as predictive of students’ PISA (Program for International Student Assessment) scores, [than] their home environment and demographics” (p. 2). PISA involved half a million students in 72 countries in 2015 and not surprisingly students with a growth mindset performed 9 to 17 percent better than those with a fixed mindset.

**Recommendations for Government Policy and Practice**

As outcomes of this study the researcher points to two significant recommendations for policy and government practice:

1. Funding for teacher professional development on mindset;
2. Scalable intervention treatments.

**Teacher professional development.**

The first recommendation is for governments to fund professional development for teachers that relates to growth mindset. Educational funding for general professional development, may not result in improved student learning outcomes, if there is not an explicit and specific focus on developing students’ and teachers’ growth mindsets. As Dweck (2015a) reminds us:

> … we risk forgetting about the psychological mechanisms that guide students’ thoughts, feelings, and behaviour to ultimately determine their academic performance. (p. 243)

Ideally, professional development could focus on the psychology of the learner, particularly their implicit beliefs of intelligence. In order to support teacher professional development, a breadth of learning resources are required. There are currently few available resources which translate social-psychological theory into teacher instructional practices. It is recommended that
professional learning include teachers discussing the summary of decades of research from The National Research Council and the Institute of Medicine (2004), which identified school conditions that promote strong student engagement and positive academic mindsets. In order for professional development to succeed, it needs to be coupled with Australian curriculum content.

**Scalable intervention treatments.**

It has been acknowledged in the literature that interventions to promote growth mindset thinking have been reasonably successful in improving educational outcomes (Paunesku et al., 2015; Baron et al., 2017). These interventions may be brief by design, however, when they tap into recursive improvement loops, the interventions result in significant and long-lasting effects on student achievement. Scalable intervention treatments schools can be cost effective. Although mindset set interventions are not a “magic bullet” (Yeager & Walton, 2011), in order to improve students’ academic outcomes it is recommended that schools be actively involved in scalable treatments addressing student underachievement and increased participation in mathematics at the senior level. This study has identified the need to integrate validated intelligence mindset programs and practices into existing school programming and instruct teachers on how to effectively foster growth mindsets. It would be desirable that schools would work in partnership with university researchers to implement and analyse mindset interventions which would be recorded on a research database. Psychological interventions offer great promise.

**Recommendations for Teacher Practice**

As a result of the findings of this study, the researcher posits a number of recommendations for teacher practice:

1. Develop shared understandings of intelligence and effort;
2. Develop a repertoire of teaching strategies that support and promote a growth mindset; and
3. Create a shared responsibility for promoting a growth mindset.
Shared understandings.

Beliefs about the nature of intelligence are critical elements in understanding the three broad questions raised by any student: Can I succeed? Do I want or need to succeed? At what cost in terms of effort expenditure? Conceptions of ability directly affects motivational patterns and outcomes (Dweck, 1986, 2000; Li & Lee, 2004). Central to the growth mindset is the recognition of effort or working hard as being necessary to develop abilities. Having a growth mindset and the desire to work at tasks are inextricably linked.

Teachers generally believe they are encouraging students when they say “put in more effort”. This study found that the learner may not clearly understand what the teacher requires as the terms effort and intelligence have a variety of meanings. Effort needs to be explicitly described to students; not just defined, but rather how effort is performed, what effort looks like, and how students know when further effort is not required. A shared understanding of the concept of effort, assists students to effectively utilise their effort to bring about improvements in their learning. The teacher must ensure that students understand and can recognise how the particular type of effort increases their learning and subsequent results.

A growth mindset, however, is not just about effort. We need to be mindful of “false growth mindsets, the misleading belief that you can do anything if you simply put in enough effort” (Chestnut et al., 2018, p. 5). A growth mindset is the belief that you can build on your ability. Building on ability relates to students being able to try new strategies, to seek help and gain explicit feedback on how to improve their work. As the student interviews revealed, effort should not be interpreted as a substitute for ability, rather effort is necessary to develop ability.

Repertoire of teaching strategies.

Implicit teaching of brain plasticity.

The implication of growth mindset for teachers, is that mastery oriented students will be more motivated to learn and to take on more challenges, than students with fixed mindsets. The challenge for teachers is to re-orientate students’ mindset beliefs and encourage growth mindset thinking. This re-orientation would include teaching lessons about brain plasticity. Furthermore,
a continuous process of teaching needs to be employed, which assists students to adopt strategies to engage with challenges that are set carefully within the learner’s Zone of Proximal Development (Adey et al., 2007). Students could be reminded that when confronted with difficult work and persist to accomplish the task, their intelligence has grown. If students understand that the brain can change with learning and that this requires effort on the part of the learner, then this may shift students from embracing a fixed mindset. In addition, genuine growth mindset training needs to be woven into primary and secondary school curricula, and most particularly in the key learning area of mathematics, a subject that communicates the strongest fixed mindset messages.

**Use of praise.**

Previous research on the use of praise (Mueller & Dweck, 1998; Gunderson et al., 2017) has been extensive and therefore it is recommended that teachers and parents use only process-praise in order to support the development of the growth mindset. Chestnut et al. (2018) suggests that what would be productive is for “teachers to focus on the process and strategies that caused a student to make mistakes, identify what went wrong, and help the student come up with more effective strategies” (p. 5).

**Growing mindset as a community responsibility.**

Attard (2017) reminds us that “numeracy and mathematics education is everyone’s business” (p. 3). As parents are the primary educators of their child, it is vital for the school to assist parents to develop a shared understanding of the concept of effort, and growth mindset. Parents often coach their children and help with homework, particularly in the primary and junior secondary years. These coaching opportunities provide parents with spaces to “actively incorporate mathematics into conversations with their children” (Attard, 2017, p. 4). As shared business, teachers are able to model best practice for parents. Teachers can actively demonstrate that mathematics is for everyone, that all students can improve in mathematics, and that individuals are not “born to do mathematics” (R. Marks, 2013, p. 31). As Boaler (2016) comments, “that single belief – that mathematics is a “gift” that some people have and others don’t - is responsible for much of the widespread mathematics failure in the world” (p. xii).
Boaler (2016) denounces the misconception that only some people are capable of studying mathematics. The misconception is “pervasive and damaging” as it implies that those people who can study mathematics are the smartest or cleverest people. This elitist view of mathematics implies that students’ intellectual capacity is judged in accordance with their perceived mathematical ability. This judgement has the potential to affect their participation in mathematics in later years. These perceptions need to be actively addressed by educators as they are still quite deeply embedded in our society’s beliefs. For example, Steele et al. (2008) reported that families saw their daughters’ who were successful in mathematics, as either “geniuses” or “aberrations” (p. 31). Students recognised in their interview responses that they were ‘different’ to the cohort. It is important to move to a future where women’s success in mathematics is ordinary or normal. As such, Attard (2017) recommends that “we need to disrupt the stereotypical perceptions of what school mathematics is and how it should be taught .... Parents need to display positive attitudes towards mathematics and learning” (p. 4).

Schools must seriously address these pervasive and damaging misconceptions. Strategies to address the misconceptions could include parent/teacher meetings, newsletters and public forums. Professional development which relates to the role and function of implicit beliefs of intelligence would be essential. In order to act as role models for the growth mindset, teachers must have a growth mindset. A cultural change of fostering a mentoring mindset amongst teachers and students could serve to guide best practices (Mullen, 2010).

Savani et al. (2017) suggests that “nearly everyone” not “only some people” can develop their intellectual potential, and should be considered as a “universal” belief (p. 1). In their daily interaction with students, Aucock et al. (2017) point out that teachers should possibly be asking: Why is this student failing or succeeding?; how might this student’s implicit theories of intelligence be instrumental in his/her failure or success?; how might my understanding of the role of mindset shape my teaching practices to facilitate maximum learning for success?
Limitations and Future Research

The composition of this sample, that is, females from a single school, limits the generalisability of the findings and requires caution about the recommendations made. This study could be extended to include other participants such as parents and teachers. The study could be repeated in an all-boys school and a co-educational school context as a comparative research study in mindset and mathematics. The location of this study was a rural town and so other elements such as geographic location, socioeconomic status and school culture could be used in new studies to contrast against the present study.

Another caution to be made is that it is not enough to provide growth mindset training for teachers and students, e.g. the online Brainology program, if the traditional mathematics pedagogy that has contributed to fixed mindsets has not been addressed. There is a danger that some teachers will teach isolated mindset or brain plasticity lessons rather than model and integrate these ideas into everyday practice. The adoption of a growth mindset pedagogy according to Rissanen, Kuusisto, Tuominen and Tirri (2018), requires teachers to support students’ individual learning processes, promote mastery orientation, promote persistence in the face of challenges and foster students’ process-focused thinking. The framework of a growth mindset pedagogy as described by Rissanen et al. may be a useful tool to guide classroom observations in future studies. It is important to continue research into how growth mindset pedagogy is actualised in schools and what are its critical points in different contexts, and most importantly what are the effects on students.

Final Comment

This study explored the issues of gendered attitudes and participation in mathematics from the perspective of implicit theories of intelligence. The students’ mindsets were complex revealing several variations on Dweck’s theory of implicit beliefs of intelligence. Having a growth mindset was significantly related with participation in mathematics in the senior years of high school which has ramifications for participation in STEM subjects at the tertiary level. Implicit beliefs or mindsets have important implications for how individuals behave in academic contexts and it is
therefore an imperative for parents and educators to understand how mindsets are formed and influenced over time. Learning environments can be created where the efficacy of effort beliefs and the emphasis on ability growth can be fostered. Growth mindset education and research is positive and optimistic heralding much promise for improvement in overall student achievement and participation in mathematics.
References


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Zhang, J., Kuusisto, E., & Tirri, K. (2017). How teachers’ and students’ mindsets in learning have been studied: research findings on mindset and academic achievement. *Psychology, 8*(09), 1363-1377.


### Appendices A: Information Letters and Consent Forms

#### Appendix 1: Information Sheet for Students and Parents

**Research Project** - Mindset and mathematics in an all-girls secondary school.

**Researcher** – Mrs Moore, Doctoral student at Charles Sturt University

**Project Supervisors** - Associate Professor Jane Mitchell and Dr Sara Murray, School of Teacher Education at Charles Sturt University.

**Invitation**

Students at XXXX College are invited to participate in a research study on mindset and mathematics.

The study is being conducted by Mrs Moore (Principal of XXXX College).

Before deciding whether to participate in this study, it is important to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish.

**The purpose of the research is to:**

1. Investigate the implicit theories of intelligence (‘mindset’) held by female students from Years 7 to 12; that is to find out whether students believe that intelligence is fixed or can be developed.
2. Understand how students think about ability, effort and achievement and its relationship to mindset.
3. Explore the relationship between students’ mindsets regarding mathematics in particular and participation in mathematics.
4. Examine students’ perceptions of the factors influencing their mindset.
The information from the study will help teachers to have a better understanding of student mindset. The results from the study will be used to inform teaching practices. The focus is on mathematics. It will lead to the development of teaching strategies to increase engagement and participation in mathematics and to achieve effective ways of encouraging students to feel positive about participating in mathematics. The results from the study will be reported in a thesis and in research articles.

**What participation will involve**

The project will involve the following: a questionnaire for students about their beliefs about effort and ability in general, in mathematics, with some general questions about learning; and an interview about students’ beliefs about ability and effort and participation in mathematics.

The questionnaire will take about 15 minutes to complete. The questionnaire will contain items such as: I don’t mind making mistakes as long as I am learning something; and I think if I work harder at school my marks will improve.

The project will also involve an interview. The interview will take about 20 – 30 minutes. The interview will include questions such as: do you think there is a limit to how much mathematics I could learn? In your normal school day is there anything that stops you working harder?

Students will be advised prior to the interview not to name other students and no information of a personal nature will be included in the research findings.

**Participation is voluntary**

Participation is voluntary. Students can choose to participate in the questionnaire or interview or both. Students can withdraw at any time and can also choose not to answer some, or all of, the questions in the questionnaire. There are no risks or benefits to students in participating in the study.

If students decide not to take part, it will not affect their results or progress in their school studies. If students or their parent/s change their mind about taking part, even after the study has started, they just let the researcher know and any identifiable information already collected will be destroyed.

If students or their parent/s decide to withdraw from the project at any time they can contact Mrs Moore, the school counsellor or the year coordinator.

**Confidentiality**

The questionnaire is anonymous. No one will be able to identify students from their answers. No one will be able to identify students from the results of the study with the exception of the major researcher (myself) who will know who the students are in the interview. All names will be removed however from the interview data. No student names or any identifying information will appear anywhere in the research results. The school will not be named in any published
articles, however the school may be identifiable because of my association with the school as principal.

All data will be kept locked in filing cabinets or on password protected computer hard drives accessible only by the researchers. All data will be destroyed after five years.

How to obtain further information

Thank you for taking the time to read this information. Mrs Moore is available to answer any questions you may have. If you would like to know more at any stage, please feel free to contact her. You can also contact Associate Professor Jane Mitchell from Charles Sturt University if you could like to find out more about the research. Her contact details are: phone 6338 4807; email jmitchell@csu.edu.au

Charles Sturt University’s Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee through the Executive Officer:
The Executive Officer
Human Research Ethics Committee
Office of Academic Governance
Charles Sturt University
Panorama Avenue
Bathurst NSW 2795
Tel: (02) 6338 4628
Email: ethics@csu.edu.au
Any issues you raise will be treated in confidence and investigated fully and you will be informed of the outcome.

This information sheet is for you to keep.
Appendix 2: Statement to be Read at the Year Assembly

I would like to invite you to participate in a research study called “Mindset and Mathematics”. The research is being conducted by Mrs Moore, our principal. All girls are invited to participate. The information from the study will be used to help our school better meet the needs of students. An information letter has been sent home to all families. There are 2 ways to participate.

What does participation involve?

1. Participation will involve completing a multiple choice questionnaire in class-time which should take 15 – 20 minutes. The questionnaire will contain items such as: I don’t mind making mistakes as long as I am learning something; and I think if I work harder at school my marks will improve.

   It is voluntary to participate in the research project and there are no consequences if you do not wish to take part. Let your teacher know if you do not wish to participate and you will be given an alternate activity to complete.

2. Participation in a 20-30 minute interview with Mrs Moore. The interview questions will be general and will include questions about effort, ability and learning. For example do you think there is a limit to how much mathematics you could learn? In your normal school day is there anything that stops you working harder?

   If you wish to take part in the interview then a slip will be available for you to fill out and a mailed invitation will be sent home to you and your parents. Participation in the interview is voluntary and will require a signed consent from yourself and your parents.
Appendix 3: Information Letter to Parents

1 March 2015

Mindset and Mathematics in an All –Girls Secondary School

Dear Parent/Guardian,

This year I am undertaking doctoral research at Charles Sturt University. My study will investigate student’s implicit beliefs about intelligence (mindset). An information sheet about the research is enclosed. The research will assist in the development of teaching practices in the school, particularly those in Mathematics classrooms.

The intention of the research is to survey all students about their attitudes about effort, ability and learning. Please note that all information provided by students is confidential. There are no names on the survey.

If you DO NOT want your daughter/s to be involved in the questionnaire then do not hesitate to let me know. Withdrawing your daughter from completing the questionnaire will not affect their progress at school in any way. If you DO NOT want your daughter to be involved in this process I would appreciate you completing the return slip. Please ensure that your daughter returns this slip to the school BEFORE 9 March 2015.

I thank you for your attention to this matter and invite you to ring me should you have any questions (63382200).

Yours sincerely

Maureen Moore
College Principal

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Mindset and mathematics in an all –girls secondary school

Dear Principal,

I have read the above letter and the attached “Parent Information Sheet” from Charles Sturt University and I have decided that I DO NOT want my child to be involved in this process. I understand that withdrawing my child from the research will not affect their progress or
standing in the school in any way. Could you please arrange for them to be omitted from the questionnaire.

My child’s name is: (PLEASE PRINT)

Parent signature: Date:

IF SUBMITTING A RESPONSE, PLEASE HAVE YOUR DAUGHTER RETURN THIS SLIP TO THE SCHOOL’S

FRONT OFFICE BEFORE 10 March 2015
Appendix 4: Parental and Student Consent Form for Interview

CSU letterhead

Mindset and mathematics in an all-girls secondary school

Researcher: Mrs Maureen Moore, Doctoral student at Charles Sturt University

Project Supervisors: Associate Professor Jane Mitchell and Dr Sara Murray, School of Teacher Education, Charles Sturt University.

I agree for my daughter……………………………………………… to participate in an interview for the above research project and give my consent freely.

I understand that the project will be conducted as described in the Information Sheet, a copy of which I have retained.

I understand that my daughter can withdraw from the project at any time and do not have to give any reason for withdrawing.

I understand that the interview will be audio-recorded.

I understand that the Principal only will know who the research participants are in the interview and that names will be removed from the interview data.

I understand that the school will not be named in the final results however the school could be identified because of Mrs Moore’s role as principal.

I may contact the principal, Mrs Moore and have any questions answered to my satisfaction regarding the research project.

Name of student (please print) _____________________________________

Name of parent (please print)  ______ ________________________________

Signature of parent: ____________________________________________

Date: ____________________________________

Consent of young person (under 18 years)

Signature of student:_____________________________________________
Charles Sturt University’s Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee through the Executive Officer:
The Executive Officer
Human Research Ethics Committee
Office of Academic Governance
Charles Sturt University
Panorama Avenue
Bathurst NSW 2795 Tel: (02) 6338 4628; Email: ethics@csu.edu.au
Any issues you raise will be treated in confidence and investigated fully and you will be informed of the outcome.
To be given to interested students after the completion of the questionnaire.

Appendix 5: Student Expression of Interest in the Interview

Interest in Interview

I am interested in volunteering to participate in a meeting with Mrs Moore to discuss what I think about effort, ability and learning. I understand that more information will be sent home and that participation will require my parent/s consent and my own.

Name: ________________________________

Year: ________________
Appendix 6: Student Consent Form for the Interview

Research Project: Mindset and mathematics in an all – girls secondary school

I (print name) .................................................................

give consent to my participation in the following part of the research project:

Interview   YES/ NO   (please circle)

Chief researcher: Mrs Moore at the College, phone 63382200

Research supervisors: Associate Professor Jane Mitchell and Dr Sara Murray

Phone – 63384820

Email: Saramurray@csu.edu.au

In giving my consent I acknowledge that:

1. The procedures required for the project and the time involved have been explained to me and any questions I have about the project have been answered to my satisfaction.

2. I have read the Student Information Sheet and have been given the opportunity to discuss the information with the researcher involved in the project.

3. I understand that my participation in this project is voluntary; a decision not to participate will in no way affect my academic standing or relationship with my school and I am free to withdraw my participation at any time.

4. I understand that my involvement is strictly confidential and that no information about me will be used in any way that reveals my identity.

Signed .................................................................

Name  .................................................................

Date  .................................................................
Appendix 7: Information Sheet and Consent Form for Teachers

Research Project - Mindset and mathematics in an all-girls secondary school.

Researcher – Mrs Moore, Doctoral student at Charles Sturt University

Project Supervisors - Associate Professor Jane Mitchell and Dr Sara Murray, School of Teacher Education at Charles Sturt University.

Invitation

All students at XXXX College are invited to participate in a research study on mindset and mathematics.

The study is being conducted by Mrs Maureen Moore (Principal of XXXX College).

Teachers are invited to participate in this project by facilitating the distribution of the questionnaire in class time and in its collection at the end of the allocated time. For your additional information, the information sheet sent to each family is included. As a reminder to students, this information sheet will also be attached to their questionnaire which is to be read by them prior to answering the multiple-choice questions.

Questionnaire distribution

The questionnaire on mindset and mathematics should take students approximately 15 - 20 minutes to complete. There are 42 multiple choice questions. Students may use either a pen or pencil to circle their response. There are no right or wrong responses.

Student completion of the questionnaire is voluntary and the questionnaire is anonymous.

If a student does not wish to participate in completing the questionnaire then there is an alternate activity for her to complete.

Please circle your response:

I consent/do not consent;

to handing out the questionnaire in my class and allowing time for the students to complete it.

Name of teacher:

Signature of teacher:
Appendix 8: Statement to be Read by the Teacher at the Commencement of the RE lesson

Last term your parents would have received a letter and information sheet from Mrs Moore outlining her research study here at XXXX College. Your parents were asked to advise us if you were not participating in the questionnaire. If this is the case for you then I will give you an alternative RE task to complete.

In this lesson today, I will be giving you 25 to 30 minutes to complete the questionnaire. The questionnaire is concerned with student mindset about effort and ability in relation to school work in general and in relation to mathematics. There are also some general questions about learning. The information sheet that was sent home to your parents and yourself is again attached to the questionnaire.

The questionnaire is anonymous so please do not write your name on the sheet.

It is a multiple choice questionnaire, so please tick your response in the box. Do not worry, there are no right or wrong answers.

A second part of the research involves interviewing students about their beliefs about effort and ability. The interview will take about 20 minutes. At the end of the questionnaire if you would like to participate in an interview with Mrs Moore about mindset and learning then please fill out the ‘interested interview’ form (yellow) that I will place on your desk and which you will need to give back to me at the end of the lesson. I will then pass these forms to Mrs Moore. If you do not wish to participate in an interview then just leave the yellow form on your desk.

Prior to interviewing, all interested students will be given an information package to take home which will require a consent form to be signed by the student and parent/s and this is to be returned to the front office. Thank-you for participating in this worthwhile research project today as it will contribute to our understanding of mindset in an all-girls secondary school.
Appendix B: Questionnaires

Appendix 9: Questionnaire – Mindset and Mathematics: Years 7 to 9

There are no right or wrong answers for this survey. We are interested in your views. Read each question carefully. Please answer every item. Thank you.

Year: (please circle) 7 8 9

Mathematics class or your math’s teacher’s name: _________________________

Please place a tick in the box that best indicates your opinion.

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<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
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</thead>
<tbody>
<tr>
<td>You can always greatly change your intelligence.</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>1. I like my work best when I can do it really well without too much trouble.</td>
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<td>2. I pride myself in being a hard worker at school.</td>
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<td>3. If I fail an assignment, I should be able to keep working on it until I pass.</td>
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<td>4. I enjoy Maths classes.</td>
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<td>5. I try hard in English.</td>
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<tr>
<td>6. I like work that I learn from even if I make a lot of mistakes.</td>
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<tr>
<td>7. I don’t ask for help because it makes me look dumb.</td>
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<tr>
<td>8. You have a certain amount of ability in Maths, and you really can’t do much to change it.</td>
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<tr>
<td>9. To tell the truth, when I work hard, it makes me feel as though I’m not very smart.</td>
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<td></td>
<td></td>
<td>Strongly disagree</td>
<td>Disagree</td>
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<tr>
<td>10. No matter how much ability in English you have, you can always change it quite a bit.</td>
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<td>11. Grades should be based in part on how much effort you put into an assessment task.</td>
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<td>12. Girls have more natural ability in English than boys.</td>
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<td>13. You have a certain amount of intelligence, and you really can’t do much to change it.</td>
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<td>14. Maths is a difficult subject.</td>
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<td>15. I feel that I belong in an English class.</td>
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<td>16. I think that students who keep trying, even in the face of failure, should be admired.</td>
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<td>17. I am interested in English.</td>
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<td>18. You can learn new things, but you can’t really change your ability in Maths.</td>
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<td>19. I would rather be admired for my ability than for my hard work at school.</td>
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<td>20. You have a certain amount of ability in English, and you really can’t do much to change it.</td>
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<td>21. I like my work best when I can do it perfectly without any mistakes.</td>
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<td>22. To tell the truth, when I work hard in Maths it makes me feel as though I’m not very smart.</td>
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<td>23. I only try hard if a task counts toward my final grade.</td>
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<td>24. You can always greatly change your ability in English.</td>
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51. I try hard in Maths. □ □ □ □

52. In this school, students who are smart are more respected than students who work hard. □ □ □ □

54. Do you think that you will choose Maths in Year 11 and 12? Please circle your response:
   Yes or No

Thank you for completing this questionnaire.
Appendix 10: Questionnaire – Mindset and Mathematics: Year 10

There are no right or wrong answers for this survey. We are interested in your views. Read each question carefully. Please answer every item. Thank you.

Mathematics class or math’s teacher’s name: _________________________

Please place a tick in the box that best indicates your opinion.

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54. Do you think you will choose Maths in Years 11 and 12? Please circle your response:  
   Yes or No

55. If Yes, circle the Maths course you think you will choose:  
   • General Mathematics  
   • Mathematics  
   • Mathematics Extension 1

Thank you for completing this questionnaire.
Appendix 11: Questionnaire – Mindset and Mathematics: Year 11

There are no right or wrong answers for this survey. We are interested in your views. Read each question carefully. Please answer every item. Thank you.

Mathematics class or math’s teacher’s name: __________________________

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<td>Survey Item</td>
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<tr>
<td>44. I like my work best when it makes me think hard.</td>
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<td>48. No matter how much Maths ability you have, you can always change it quite a bit.</td>
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<td>❑</td>
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</tr>
<tr>
<td>51. To tell the truth, when I work hard in English, it makes me feel as though I’m not very smart.</td>
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<td>❑</td>
<td>❑</td>
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</tr>
<tr>
<td>52. I try hard in Maths.</td>
<td>❑</td>
<td>❑</td>
<td>❑</td>
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</tr>
<tr>
<td>53. In this school, students who are smart are more respected than students who work hard.</td>
<td>❑</td>
<td>❑</td>
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<td>❑</td>
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</tbody>
</table>

**There are four remaining survey items.**

**Please turn to page 5 to complete the survey.**

54 (a). Is Maths one of your subjects this year? Please circle your response:

Yes or No
54 (b). If Yes, please circle the Maths course you are taking:
  - General Mathematics
  - Mathematics
  - Mathematics Extension 1

55 (a). Will you continue to take Maths in Year 12? Please circle your response:
  - Yes
  - No

55 (b). If yes, please circle which Maths course you will most likely be taking in Year 12?
  - General Maths 1 (non ATAR course)
  - General Maths 2 (ATAR)
  - Mathematics
  - Mathematics Extension 1
  - Mathematics Extension 2

Thank you for completing this questionnaire.
Appendix 12: Questionnaire – Mindset and Mathematics: Year 12

There are no right or wrong answers for this survey. We are interested in your views. Read each question carefully. Please answer every item. Thank you.

Mathematics class or math’s teacher’s name: _________________________

Please place a tick in the box that best indicates your opinion.

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<tr>
<td>2. I like my work best when I can do it really well without too much trouble.</td>
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<td>3. I pride myself in being a hard worker at school.</td>
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<td>4. If I fail an assignment, I should be able to keep working on it until I pass.</td>
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<td>5. I enjoy Maths classes.</td>
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<td>6. I try hard in English.</td>
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<td>7. I like work that I learn from even if I make a lot of mistakes.</td>
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<tr>
<td>8. I don’t ask for help because it makes me look dumb.</td>
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<tr>
<td>9. You have a certain amount of ability in Maths, and you really can't do much to change it.</td>
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<td>10. To tell the truth, when I work hard, it makes me feel as though I'm not very smart.</td>
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<td>11. No matter how much ability in English you have, you can always change it quite a bit.</td>
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<td>12. Grades should be based in part on how much effort you put into an assessment task.</td>
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<tr>
<td></td>
<td></td>
<td>Strongly disagree</td>
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<td>13. Girls have more natural ability in English than boys.</td>
<td></td>
<td>☐</td>
<td>☐</td>
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<td>14. You have a certain amount of intelligence, and you really can’t do much to change it.</td>
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<td>☐</td>
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<tr>
<td>15. Maths is a difficult subject.</td>
<td></td>
<td>☐</td>
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</tr>
<tr>
<td>16. I feel that I belong in an English class.</td>
<td></td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>17. I think that students who keep trying, even in the face of failure, should be admired.</td>
<td></td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>18. I am interested in English.</td>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>19. You can learn new things, but you can’t really change your ability in Maths.</td>
<td></td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>20. I would rather be admired for my ability than for my hard work at school.</td>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
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<tr>
<td>21. You have a certain amount of ability in English, and you really can’t do much to change it.</td>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>22. I like my work best when I can do it perfectly without any mistakes.</td>
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<td>☐</td>
<td>☐</td>
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<tr>
<td>23. To tell the truth, when I work hard in Maths it makes me feel as though I’m not very smart.</td>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>24. I only try hard if a task counts toward my final grade.</td>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
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<tr>
<td>25. You can always greatly change your ability in English.</td>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
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<tr>
<td>26. I am mainly interested in the marks I get, not the teachers’ comments on my work.</td>
<td></td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>27. I would rather be thought of as smart than hard working.</td>
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<td>28.</td>
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<td>☑</td>
<td>☑</td>
<td>☑</td>
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<tr>
<td>30.</td>
<td>When something is hard, it makes me want to work more on it, not less.</td>
<td>☑</td>
<td>☑</td>
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<tr>
<td>31.</td>
<td>Anyone can be excellent at Maths if they work at it.</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>32.</td>
<td>I am proud to admit how hard I work at school to other people.</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
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<tr>
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<td>I enjoy English classes.</td>
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<td></td>
<td>who work hard.</td>
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</tbody>
</table>

There are four remaining survey items.

Please turn to page 5 to complete the survey.
54 (a). Did you take Maths in Year 11? Please circle your response:

Yes or No

54 (b). If Yes, which course did you take?

- General Maths
- Mathematics
- Mathematics Extension 1

55 (a). Are you doing Maths in Year 12? Please circle your response:

Yes or No

55 (b). If Yes, circle the Maths course you are doing:

- General Mathematics 1 (non ATAR)
- General Mathematics 2 (ATAR)
- Mathematics
- Mathematics Extension 1
- Mathematics Extension 2

Thank you for completing this questionnaire.
Appendix C: Student Interview Questions

Appendix 13: Statement to be Read to Student Prior to Interview

Hello, thank-you for volunteering to be interviewed for the mindset and mathematics research project.

There are about 21 questions in all and it should take us only 20 minutes or so. Feel free to say for any particular question that you do not want to answer the question. If at any time you do not want to answer any more questions just let me know that you do not want to answer any more questions and that you would like to return to class.

Speak only about what you are comfortable with. There are no right or wrong answers so don’t feel anxious. I am only interested in your ideas and opinions. There are no personal questions and no questions about other people. Your answers are confidential and are not reported to anyone in the school. Pseudonyms are used for the report, that is, names are made up without surnames. All student interviews will therefore be anonymous.

I would just ask that you do not mention the names of any students or teachers. If a name does get mentioned it will be deleted from the interview.

Let’s start with some general questions:

1. What are your favourite subjects?

   What do you like about x............ That’s great!

2. Do you find some subjects easier than others? Which ones do you find easier? Why do you think that is?

3. Why do some people do better at school than others?

Now I am going to ask more specific questions; take your time:

4. Questions 4-7 exploring this question in more depth. Ask as necessary. What does the word ‘intelligence’ (or whatever word the student uses) mean to you? What does
‘effort’ (whatever the word the student uses) mean – if someone works hard (the word the student uses) at school, what are they actually doing?

(If the student does not mention ability (intelligence) or effort) say “some important concepts central to my research are the meaning of intelligence and effort”.

What does the word intelligence mean to you? (at school)

What does the word effort mean to you at school?

Outcome: definitions/understanding of what intelligence means?
Definitions/understanding of what effort means?

5. Role of effort/ working hard and intelligence/being smart play in doing well at school? (Their words for intelligence, effort )

   a) What role does effort or work play in doing well at school?

   b) What role does intelligence or being smart play in doing well at school?

   c) Is one more important than the other?

   d) Can you give a percentage to each?

   Outcome: relative contributions of intelligence and effort in school success (tell be about what role these play; is one more than the other?)

6. If somebody studies a lot;
   a) Will they become more intelligent?

   b) Does working harder mean that they can get smarter?
**Outcome: Can intelligence/smartness grow with effort**

**Let’s talk a bit about working at school:**

7. Do you think you work hard at school? Can you tell me a bit more about that? What does working hard involve?

8. In your normal school day is there anything that helps you to work hard or make an effort?

9. What things stop you from making an effort or working hard at your school work?

10. Would you rather be thought of as ‘smart’ or ‘hard working’? What are your reasons for this?

11. In this school, who is respected more, students who are smart or students who work hard? That’s really interesting can you tell me a bit more about that?

12. In your group of friends is it OK to work hard at school? Why do they think this?

13. Are you considering taking Maths in Years 11 and 12? Why or why not?

**Now let’s talk about Maths**

14. Do you like Maths? Why?

15. Do you do well at Maths? Why is that?

16. Do you think Maths is an easy or difficult subject? Why do you think this?

17. What do you find easy or difficult about it?

18. Is Maths harder or easier than other subjects?
19. Can someone get better at Maths? How could they do this?

20. Do you think that being good at Maths is something you’re born with or do you develop it over time? Why?

21. Do you think girls and boys are equally good at Maths? Why?

22. What influenced your decision to take or not take Maths in Years 11 and 12? Parents, friends, school.

23. Have your views about how good you are at Maths influenced your Maths choices?

Thank-you, your answers have been very insightful and I appreciate your participation in this project.
Appendix D: Factor Analysis
<p>| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .906 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 8118.242 |
| df | 780 |
| Sig. | .000 |</p>
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<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings*</th>
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<td>% of Variance</td>
<td>Cumulative %</td>
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<td>7.800</td>
<td>33.313</td>
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Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.
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- Item 32: I am proud to admit how hard I work at school to outwork other people
- Item 37: My grades are the result of effort and hard work
- Item 41: Boys have more natural ability in Math than girls
- Item 46: It's not cool in my group of friends to try hard in class


a. Rotation converged in 27 iterations.
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**Extraction Method:** Principal Component Analysis.  
**Rotation Method:** Oblimin with Kaiser Normalization.

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<td>.167</td>
<td>.179</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**Extraction Method:** Principal Component Analysis.  
**Rotation Method:** Oblimin with Kaiser Normalization.

```factor
/VARIABLES Q1 Q14R Q35 Q50R Q3 Q8R Q24R Q26R Q32 Q37 Q39R Q43R Q20R Q5 Q29 Q36 Q6 Q16 Q18 Q33 Q9R
```
Appendix E: Ethics Approval

October 13 2014

Dear Maureen,

Thank you for your letter of October 6 in which you provide details in regard to your Doctoral Research Proposal. I am delighted to hear that your presentation of candidature was successful. Thank you also for taking the time to meet with me on October 10 to discuss more fully your Research Proposal.

I am fully supportive of both the broad aim of your study and the methodology you propose. Your investigation into the implicit theories of intelligence (mindset) resonate beautifully with the educational philosophy underpinning the current system-wide initiatives within our diocese, so I will be particularly interested in following the progress and outcomes of your research.

I also fully endorse the approach you are taking in conducting the research within your current school community. I am fully satisfied that you are adopting an ethical approach and I see great value within the context of your research topic, in undertaking this within your school community.

With my congratulations for the work you have undertaken to date and I look forward to supporting your endeavours in relation to this Doctoral activity.

Every best wish,

Jenny Allen
Executive Director of Schools
16 February 2015

Mrs Maureen Moore
4 Glenhaven Crescent
PERTHVILLE NSW 2795

Dear Mrs Moore,

Thank you for the additional information forwarded in response to a request from the Human Research Ethics Committee (HREC).

The CSU HREC reviews projects in accordance with the National Health and Medical Research Council’s *National Statement on Ethical Conduct in Research Involving Humans*.

I am pleased to advise that your project entitled “Mindset and mathematics in an all-girls secondary school” meets the requirements of the *National Statement*, and ethical approval for this research is granted for a twelve-month period from 13 February 2015.

The protocol number issued with respect to this project is 2015/008. Please be sure to quote this number when responding to any request made by the Committee.

Please note the following conditions of approval:

- all Consent Forms and Information Sheets are to be printed on Charles Sturt University letterhead. Students should liaise with their Supervisor to arrange to have these documents printed;
- you must notify the Committee immediately in writing should your research differ in any way from that proposed. Forms are available at: [http://www.csu.edu.au/__data/assets/word_doc/0012/963768/Report-on-Research-Project_20130503.doc](http://www.csu.edu.au/__data/assets/word_doc/0012/963768/Report-on-Research-Project_20130503.doc) (please copy and paste the address into your browser);
- you must notify the Committee immediately if any serious and or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project. An Adverse Incident form is available from the website: as above;
- amendments to the research design must be reviewed and approved by the Human Research Ethics Committee before commencement. Forms are available at the website above;
• if an extension of the approval period is required, a request must be submitted to the Human Research Ethics Committee. Forms are available at the website above;
• you are required to complete a Progress Report form, which can be downloaded as above, by 18 November 2015 if your research has not been completed by that date;
• you are required to submit a final report, the form is available from the website above.

YOU ARE REMINDED THAT AN APPROVAL LETTER FROM THE CSU HREC CONSTITUTES ETHICAL APPROVAL ONLY.

If your research involves the use of radiation, biological materials, chemicals or animals a separate approval is required from the appropriate University Committee.

The Committee wishes you well in your research and please do not hesitate to contact the Executive Officer on telephone (02) 6338 4628 or email ethics@csu.edu.au if you have any enquiries.

Yours sincerely

[Signature]

Julie Hicks
Executive Officer
Human Research Ethics Committee
Direct Telephone: (02) 6338 4628
Email: ethics@csu.edu.au
Cttee: Associate Professor Jane Mitchell Dr Sara Murray

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007)