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Developing Mathematical Identities: Australian Children's Gendered Constructs in the First Formal Year of School

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Developing Mathematical Identities: Australian Children's Gendered Constructs in the First Formal Year of School

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Statement of Original Authorship

I, Rachelle Glynn, declare that the work contained in this thesis, submitted in fulfilment of the requirements of the award of Doctor of Philosophy, in the School of Education, University of Notre Dame Australia is wholly my own work. To the best of my knowledge, the thesis contains no material previously published or written by another person except where due reference is made.

Signed

Rachelle Glynn

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I would like to acknowledge Helen Forgasz and Gilah Leder for their development of the *Who and Mathematics* instrument and also their prolific contribution to the study of mathematics and gender in Australia. The reference list demonstrates how much value I have found in their work and hope that I have done it some justice.

To my family, Mum and Dad, you are no doubt gobsmacked that the teary 16-year-old frustrated with mathematics homework, and with no belief that I could become a 'maths person' has produced a thesis on mathematics education. Despite all my research on mathematics identity, I am not entirely sure how this happened either, but I am greatly appreciative of your love, support and patience throughout. To Denis, Bronwen, Gaylene and Trevor for faithfully asking about the progress of the PhD in every phone call. To my colleagues at the University of Notre Dame for everyday inspiration, encouragement and humour, you are truly the best people to work with and I consider myself very lucky.

Finally, Matt, you are the best teammate I could have hoped for, you knew just the right moment to give me some encouragement, and your smile has kept me going when this thesis seemed beyond my capabilities. Now, we have Sundays back.

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Abstract

Researchers have been intrigued by the dichotomy of similar achievement levels between boys and girls but disparate mathematical attitudes, which show that girls are much less likely to enjoy or engage with mathematics or choose professions involving mathematics (Kyriacou & Goulding, 2006; Vale, 2008). Although studies have explored differences in boys' and girls' perceptions of their mathematical identity from age seven, there has not been research conducted on students as they begin school to see what gendered perceptions they bring to their mathematical learning. This study seeks to answer the question: *How are girls' and boys' mathematical identities being informed as they begin school in Australia?*

This study used a mixed-methods multiphase case study methodology and surveyed participants in three primary schools in Sydney, Australia. Kindergarten is the first formal year of school in New South Wales, Australia and children are aged between four - six years old. Participants in the study included 78 Kindergarten students (boys=39, girls=39), the Kindergarten cohort's parents (mothers=50, fathers=11) and the Kindergarten students' teachers (n=7). A child-friendly adaptation of the *Who and Mathematics* instrument (Leder & Forgasz, 2000) was developed for this study and used to assess the children's understandings of their mathematical identity and association with gender. Parents and teachers were surveyed using the *Who and Mathematics* instrument to determine correlations between parents', teachers' and children's views. In addition, parents participated in a follow-up interview, which was used to determine themes from their responses. The children were then surveyed again at the end of the school year to see if their views had changed. Critical theory provided the theoretical framework for this research as a means of understanding *what is* and contrasting it with *what should be*. Thus, this enables the study's aim to interrogate the potential inequalities surrounding Kindergarten students, specifically related to mathematics, with the intention of proposing interventions.

The results of this study showed that both boys and girls began school confident that their own gender would be successful at mathematics. This changed by the end of the year as girls became less confident in their mathematical aptitude compared to boys. Girls' mean response also changed from believing that mathematics would be important for their future job opportunities to believing that this would be more important for the boys. There was also some alignment between the children's views and the views of parents and teachers by the end of the year, which conformed to stereotypes. These results show that children's gendered beliefs about

mathematical identity begin at an earlier age than previously reported. Children are absorbing and cultivating stereotypical gendered views from significant adults around them as early as the first year of school. The implications are that the early years of education must be understood to be a critical and formative time for the development of children's mathematical learner identities. Equipping parents, teachers and schools with the tools needed to help all learners develop a healthy relationship with mathematics could prevent the onset of the 'leaky pipeline' of females disengaging with mathematics and mathematical careers.

Chapter One: Introduction

1.1 Overview

As children compose their mathematical identity, formative people, experiences and the environment help to co-construct their beliefs about inherent mathematical aptitude and capabilities. Cobb (2004) asserted that mathematical identity should be a central issue for mathematics educators as, over time, a child's mathematical identity will inform a sense of who they are as learners and whom they could become. Understanding these influences and examining whether there is a perpetuated message that systematically excludes particular students can assist mathematics educators to develop an inclusive and welcoming mathematical environment. This could enable all students to forge a healthy relationship with mathematics, allowing them to reach their potential.

Gender stereotyping in mathematics is particularly significant as it is interconnected with students' mathematical identity (Vale, 2010; Wienk & O'Connor, 2020). Students who perceive they are less capable due to an inherent deficit learn to believe their weakness in mathematics is a foregone conclusion (Pinxten et al., 2014; Thomson et al., 2013; Vale, 2008). There are two processes that are occurring simultaneously and symbiotically. First, if there is a perception that, due to your gender, you are less mathematically able, then it is a reasonable assumption to make that the mathematics space is not made or meant for you, it is for other people who are inherently better and able to participate more successfully. To continue trying is to continue to experience failure. It is the square peg in the round hole. This alienation drives students' disengagement and lowers their motivation to participate, and withdrawal becomes a logical choice to manage the expected failure. The second process that occurs is that lack of participation and engagement leads to poorer mathematical results, reinforcing the notion that mathematical success is out of reach, as expected, propagating a vicious cycle.

This thesis explores how mathematical identity and gender intersect in the formative years of Kindergarten, which is the first year of formal education in New South Wales (NSW), Australia. Understanding the messages that students receive about their mathematical identity and capability helps to capture the way mathematical identity is shaped and can pinpoint messages that create obstacles for children as they find their place as mathematical learners. Table 1.1 outlines the overview of Chapter One.

Table 1.1

Overview of Chapter One: Introduction

1.1	Overview
1.2	Background and Context
1.3	Purpose and Scope of this Research
1.4	Research Questions
1.5	Significance
1.6	Limitations
1.7	Overview of the Theoretical Framework
1.8	Outline of the Thesis

1.2 Background and Context

In 2015, I was finishing an evening of parent-teacher interviews for my Year Four class when a comment from a mother intrigued me. We were discussing her daughter's progress, generally at first and then more specifically regarding mathematics. Her daughter was doing reasonably well in mathematics and was above average in the class. As I began to explain this, the mother cut me off and said to me: "Well, you know she's no good at maths because she's such a girly girl, her sister is better, she's more of a tomboy y'know." The comment struck me as intriguing for three reasons. First, the mother assumed that mathematics was a male domain. Second, she expected that I would agree with her and that this was a commonly held belief, or perhaps even a fact. Third, she did not acknowledge the information I was presenting about her daughter's accomplishments in mathematics. Her own personal beliefs meant she disregarded the information being presented to her so that even though I was telling her that her daughter was doing quite well, I was sure she walked away still believing her daughter was a poor mathematician. I wondered afterwards if her daughter heard her mother speaking about her capabilities and more generally, girls' capabilities like this, that eventually she would believe this herself and this would become a self-fulfilling prophecy. Why persevere in a subject that you are inherently ill-equipped for? Subsequently, if one parent viewed mathematics as a male domain, how many more might also believe this?

Access and equity are two critical concerns for educators. Creating equitable classroom environments for learners relies on understanding learners' needs, including their self-perceptions. In addition, women are consistently under-represented in science, technology, engineering and mathematics (STEM) fields of study and employment (Spearman & Watt, 2013). It is evident that the intention of access and equity is not being realised for girls as they move through school and make choices about further study and career interests.

1.3 Purpose and Scope of this Research

This mixed-methods case study set out to determine the way in which Kindergarten-aged children are given messages regarding their mathematical ability and whether there are differences to these messages, based on their gender. Mathematics was the area selected due to the decline in engagement and participation as girls progressed throughout school. The intention was to discover when girls began to disengage or to reference the leaky pipeline analogy (discussed in Section 2.1.4), when do the cracks first appear? By viewing the resulting data through the lens of critical theory, causality can be ascribed, and the construction of mathematical self-concepts and identities for boys and girls can be better understood. This understanding can then be used to transform the parents' and teachers' behaviours and enable children to forge a more positive mathematical self-concept that is not constrained by gendered stereotypes. This could be applied generally as a reflective approach in any school setting to understand if gendered messages are being shared. It should be noted though that while the results of this case study will not necessarily be transferable to other school communities, the general principle of looking in to a school community to understand the way children develop their learner identity could provide a useful framework for other school communities. The scope of this study includes significant role models for children at this early age. That is parents and their first school teacher/s.

The proposed outcomes of the current study are:

- To understand and elucidate the perceptions of mathematical characteristics of girls and boys as they begin school from the perspective of parents, teachers and the students themselves.

- To understand if or when students are receiving stereotypical messages from significant role models that influence the development of their learner identity.
- To make recommendations that are responsive to the findings to ensure the principles of access and equity for students.

1.4 Research Questions

The research questions sought to determine if parents and teachers hold gendered beliefs about children's inherent capabilities and self-concept in mathematics. The literature review in Chapter Two will establish the ways that mathematics has historically been viewed as a male domain (Osen, 1974). Chapter Two also details many interventions over the years as an attempt at inclusivity, to engage girls more, encourage greater participation and seek to stop the gaps and reduce the trickles from the leaky pipeline of young women disengaging with mathematics. However, a substantial portion of the literature asserts that stereotypical thinking about mathematics and gender persist (Leder & Forgasz, 2010; Vale, 2002). This study sought to confirm this view and understand if and when this view is transmitted to children. In addition, this study attempted to understand what children in their first year of school perceive about their gender in relation to mathematics. As the idea of gender is explored, an important consideration to note is that due to the ages of the children involved (five – six years), a binary understanding of gender was utilised. At this stage of development, it could not be expected for the children participating to have a sophisticated or nuanced understanding of gender, and so, only the terms 'boy' and 'girl' were used.

The main research question for this study is:

How are girls' and boys' mathematical identities being informed as they begin school in Australia?

The subsidiary research questions are:

- **What are parents' and teachers' views of girls' and boys' mathematical identities?**
- **How are boys and girls describing their mathematical capabilities and relationship with mathematics at the beginning and end of their first year of school?**
- **What is the relationship between the views that parents, teachers and children hold regarding gender and identity?**

1.5 Significance

This study can assist teachers and parents improve the way they think about and discuss mathematics in the early years of schooling. This is important so that all students are appropriately supported to develop healthy mathematical identities.

Chapter Two: Literature Review will outline the body of research that has been amassed on boys' and girls' self-concept, self-efficacy and emotions to do with mathematics. The literature focused on children after Year 2 (aged seven). It is reasonably challenging to collect data from participants younger than this if they cannot yet read or write. This may be why researchers have traditionally involved older participants. However, the gap in the literature is regrettable, as knowing when negative self-concept begins and how this is communicated to and received by children would be valuable to understand. The current study involves participants in their first year of formal education (aged four- six years) and is the first known study on this topic to do so. The significance of this is that it can be precisely understood when negative self-views about mathematics become embedded in the child's learner identity. If an established timeline of negative messages and their uptake is clear, it is reasonable to expect that teachers and parents can intervene at a more appropriate time, rather than years after negative self-concepts have developed and been consolidated.

The development of the children's version of the *Who and Mathematics* instrument also contributes to the literature and may be a useful tool for further research. The original *Who and Mathematics* instrument was designed in 2000 by Leder and Forgasz to update a previous instrument, the *Mathematics as a Male Domain* subscale of the Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976). Leder and Forgasz (2000) made revisions to allow for participants to select responses for females, rather than limiting responses to *male* or *neutral* as the Fennema- Sherman instrument had. This instrument has been validated and used multiple times internationally, allowing researchers to compare and contrast data from different countries and social settings. The development and introduction of the child-friendly *Who and Mathematics* instrument in the current study now enables young participants to be included as it uses inclusive language and it does not rely on the ability of the child participant to read or write.

1.6 Limitations

As in all case studies, there is a limitation to the generalisability of this research (Cohen et al., 2013). Therefore, the findings in this study cannot be imposed on other school communities. The unique social and cultural contexts specific to schools mean that the findings may be different. There are other instances with studies utilising the *Who and Mathematics* instrument where cultural and social background have impacted the views of the participants (Barkatsas et al., 2002). As Shen (2009) stated, "the purpose of case study is not to represent the world, but to represent the case" (p. 22). However, while the results of the participants' views could not be applied to other cases, there is value in consideration of a 'best practice' that may be used in all school contexts to identify mathematical identities held by learners as a type of learner health check to establish what intervention if any, may be needed. There is also value in comparing cases to see where interventions may be working, or situational elements may be exacerbating poor outcomes for learners.

The gender balance of participants in this study would ideally be equal. However, primary school teachers are typically female. The Centre for Education Statistics and Evaluation (CESE) data show that in 2020 in Australia, 72.4% of primary school teachers were female. In addition, it is still typical for the mother to be the primary point of contact, and in this instance, this means that they were more likely to respond to the survey sent via the schools' communication app.

1.7 Overview of the Theoretical Framework

The theoretical framework that has been utilised is critical theory. Critical theory seeks to understand an existing situation and transform the situation into one that encourages inclusion and agency for all participants. Habermas (1972) defined critical theory as having an 'emancipatory interest'. This is in contrast to the characteristics of theories associated with positivist and interpretivist paradigms which Habermas (1972) considered had scientific or practical interests. Morrison (1995) built on this idea and claimed that critical theory should have an ideological function and that the research constructed using a critical theory lens is not neutral. Kincheloe (2012) said that this emancipatory intention is concerned with praxis, action that is "informed by reflection with the aim to emancipate" (p. 177). The assumption is that the existing power structures prevent individual and social freedoms and need to be exposed to attain the ideal state of social justice. In this case study, the research questions are directed at understanding whether there is equity in school settings. The overarching aim is to enable intervention that will promote equity and access for all students. This will be elaborated on in Chapter Two: Literature Review.

1.8 Outline of the Thesis

Chapter One is the introduction to the current study. It described the researcher's background and interest in undertaking this study. The research questions have been stated and situated in the context of the mixed methods case study. This context was then linked with the theoretical framework of critical theory. Further to this, the significance of the study was presented. In particular the contribution to the field in developing a child-friendly *Who and Mathematics* instrument for young children. This allows young children's voices to be heard in a field of research that is traditionally focused on older students aged seven and above. Finally, the research outcomes and limitations of the present study were outlined.

Chapter Two will introduce the literature related to the current study. The literature review outlines the historical perspectives on gender and mathematics since the 1970s. Chapter Two is organised thematically to understand how children come to understand and develop their mathematical identity. The four sub-sections are:

- Who is a ‘maths person’?
- Who thinks they are a ‘maths person’?
- Who is told they are a ‘maths person’?
- Who becomes a ‘maths person’?

Chapter Three presents the methodological choices in this study, with in-depth detailing of why select choices were made. It discusses the paradigm of pragmatism as well as critical theory and the choice of the mixed methods multiphase case study including the decision-making that led to this selection.

Chapter Four focuses on the subsidiary research question: *What are parents’ and teachers’ views of girls’ and boys’ mathematical identities?* The chapter focuses on the parents’ responses and presents the findings on their views on gender and mathematics through their responses to the *Who and Mathematics* survey. Data from a follow up semi-structured interview conducted with parents are also presented to provide insight into their initial responses to the

Who and Mathematics instrument. Their responses are then categorised into five themes that are continued throughout the remainder of the thesis. These are; self-concept, aptitude, encouragement from role models, enjoyment, relevance to later life.

Chapter Five answers the research sub-questions: *How are boys and girls describing their mathematical capabilities and relationship with mathematics at the beginning and end of their first year of school?* and *What is the relationship between the views that parents, teachers and children hold regarding gender and identity?* A modified and child-friendly version of the *Who and Mathematics* instrument was developed and used with the Kindergarten student participants. The interview was conducted twice, at the beginning of Term 1 and the end of Term 4, to see if perspectives had changed across the year.

Chapter Six presents a preliminary investigation into teachers' perspectives of gender and mathematics. Teachers of the children who participated in the study were surveyed using the *Who and Mathematics* instrument to see if there was any alignment in their responses compared to the children's responses.

Chapter Seven discusses the parents', children's and teachers' responses regarding the subsidiary research questions with respect to the themes used throughout of self-concept, aptitude, enjoyment, encouragement from role models, and relevance to later life. Each theme is discussed through the lens of critical theory to understand the 'false' or 'fragmented' consciousness of the participants (Eagleton, 1991). This chapter will culminate with a response to the overarching research question: *What are parents' and teachers' views of girls' and boys' mathematical identities?*

Chapter Eight presents the main understandings from the study. This chapter concludes the study by drawing together the most significant findings in the hope of usefulness for all stakeholders. Limitations and suggestions for further research are also noted.

Chapter Two: Literature Review

2.1 Overview

This chapter explores the historical traditions of mathematics as a male domain. It then goes on to understand mathematical identity and the social construct of a 'maths person'. It explores literature to understand whether there are any reasons to believe that some people may be inherently more talented in mathematics than others, and also outlines some of the ways that messages about mathematical identity have been shared by significant role models, both internationally and in Australia. As the literature is reviewed, and sources that inform children's mathematical identity are understood, the conceptual framework will be constructed to show influences on children as they develop their mathematical identity.

Table 2.1

Overview of Chapter Two: Literature Review

2.1	Overview
2.2	The Tradition of Mathematics and Men
2.3	Who is a 'Maths Person'?
2.4	Who Thinks They are a 'Maths Person'?
2.5	Who is Told They are a 'Maths Person'?
2.6	Who Becomes a 'Maths Person?'
2.7	Adding to the Conceptual Framework
2.8	Summary of Literature
2.9	Theoretical Framework

2.2 The Tradition of Mathematics and Men

This literature review will demonstrate that over the course of Western history, women's access to and participation in the domain of mathematics has been limited. Nevertheless, there have been some women who have made their mark on the mathematical world. Emilie du Chatelet (1706 – 1749), Maria Agnesi (1718 -1799), Sophie Germain (1776 – 1830), Mary Somerville (1780 – 1972) and Ada Lovelace (1815 – 1852) are some of the noteworthy women who lived in the 17th and 18th centuries and whose contributions to the field of mathematics are still considered important (Leder, 2019a). While it is important to acknowledge these contributions, it should also be noted that women were not encouraged into the world of mathematics and these women were tenacious exceptions rather than the rule, in a society that focused on educating young men and preparing young women for domestic roles (Osen, 1974).

The seminal book, *Men of Mathematics* by Bell (2014), originally published in 1937, dedicated a chapter to each mathematician from the 17th to 19th century that had made a significant contribution to the field. Interestingly, given the book's title, one of the chapters provided a biography and anecdotes of Sonja Kowalewski, a female mathematician. Her achievements were considered so crucial that they warranted being included in the book despite her gender, but not important enough to influence the publishers to use a more inclusive title such as *Lives of Mathematicians* as Bell had originally wanted (Reid, 1993). Bell's book could be seen as a sign of the times, given that it was first published in 1937. *The Mathematical Experience*, written in 1981 by Davis and Hersh, had a more inclusive title than *Men of Mathematics*. However, this is where a more equitable attempt at including women ended. It included 66 mathematicians, all of whom were male. *The Mathematical Experience* is still available for sale today and is currently described on the dust jacket as "...a perfectly marvellous book … from which one will get a real feeling for what mathematicians do and who they are…" and also a "classic introduction for the educated lay reader to the richly diverse world of mathematics: its history, philosophy, principles, and personalities" (Davis et al., 2012, book cover). This description is quite apt, claiming that it accurately pinpointed 'who' mathematicians were. They were male. The description of *The Mathematical Experience* as a "richly diverse world of mathematics" (Davis et al., 2012, book cover) exposes a truth that historically, diversity in mathematics was celebrated but diversity amongst mathematicians was not.

2.2.1 The 1970s and 1980s: Progress for Women

Wider attention to women's rights in the 1970s coincided with more scholarly attention to gender issues in mathematics education (Leder, 2019a). The influential work of Fennema in the 1970s inspired a great many researchers to analyse the role of social structures, educational opportunity and pedagogy, many of which were found to be biased towards boys (Leder, 2019a). Fennema's 1974 review of mathematics learning and gender analysed 36 studies of mathematics performance and showed that there were no significant differences between boys' and girls' mathematical achievement in the early years of school. However, as boys and girls moved into high school, boys were shown to be more successful in mathematical tasks considered to be more cognitively demanding (Fennema, 1974). Fennema concluded that her review raised more questions than answers and speculated on the role that sexism played in these findings. Many of the recommendations that came out of Fennema's 1974 research encouraged equality in the field of mathematics education and an acknowledgement that girls should be provided with the same opportunities as boys. This was known as the assimilationist model (Leder, 2019a). Within a few years, Sells (1980) suggested that mathematics was a 'critical filter' and for those who were able to access it, it was a means of promoting access to high-income and high-status careers. Fennema's 1974 findings had forecast that access to mathematics was an issue of inequality. Sells' 1980 proposition of mathematics as a critical filter illustrated a key reason for girls and women to be included more readily in mathematics education.

The 1980s saw a more nuanced view of gender and mathematics that acknowledged the gender inequities and power structures beyond the classroom. The implication being that schools, pedagogy and curriculum had been established to favour males. The deficit model of girls needing to 'assimilate' and catch up in this environment shifted to an acknowledgement that schools should be a place that helped combat inequities (Fennema et al., 1980). Efforts and interventions were made that more specifically focused on female participation. Fennema et al. (1980) developed an intervention compendium which was a widely used resource for students, teachers, parents and counsellors. The researchers described its objectives as three-fold (Fennema et al., 1980, p. 4):

1. To inform students, teachers, parents, and counsellors of the utility of mathematics and its relationship to opportunities in later life. To do so, they believed that it was fundamental to educate all cohorts on the underlying mathematical stereotypes impacting attitudes such as female high school students' lack of confidence in learning mathematics, the ways that mathematics is stereotyped as a male domain, stereotypical attitudes toward females as learners of mathematics, differential treatment of females and males in mathematics classes, and stereotypical portrayal of females and males in curriculum documents.
2. To motivate teachers, counsellors, and parents to achieve change.

3. To provide each cohort with knowledge of specific activities that could help to change students' mathematics-related behaviour.

2.2.2 The 1990s and Policy Change

The attention to intervention in the 1980s continued into the early 1990s. In 1990, Leone Burton collated mathematical research from fifteen countries to consider the international mathematical experience in classrooms. Burton intended to review the lens under which mathematical content was being taught, and to understand how educators interpreted the syllabus and determined mathematical pedagogy. The publication of these papers showed subtle but inconsistent pedagogical differences from country to country that typically reflected the cultural and social values in broader society, typically favouring males. For example, in the Australian context, Leder (1990) contributed to Burton's collection of works with a paper showing that males in Australian secondary schools both contributed to class discussions more regularly and were called on to answer questions more regularly, showing that boys and girls were treated differently in mathematics classrooms. Taylor (1990) painted a picture of American college life with more overtly sexist comments from a mathematics professor proclaiming that women should not be in the mathematics course (there were only two women out of 60 students) and that he would do what he could to flunk them. An alternative was presented in a paper from the Netherlands (Verhage, 1990), after a systematic attempt to reform the mathematics curriculum to provide greater context and connection for both girls and immigrants. Verhage (1990) described lessons on symmetry using embroidery skills which dismayed the boys in the class and delighted the girls with both groups devaluing the skill of sewing, seeing as it was considered 'women's work' and not 'real' mathematics. Particular thought was put into delivering learning experiences that challenged the traditional delivery of mathematics and were beneficial for all students in the class.

Burton (1990) wanted to find trends in mathematical pedagogy around the world. In doing so, the value that each country and its educators placed on mathematics education for all students was given a spotlight, showing that bias towards boys was still the case more often than not. Burton's contribution to the dialogue expressed the view that girls, and the way they know mathematics is different. In addition, she claimed this difference had the potential to enrich mathematics for all students if allowed to flourish. Burton (1995) made a distinction about the way that girls approach mathematics and learn best. Importantly, she claimed that it was different to the way that boys ‘know’ mathematics as girls place more focus on social connections and meaning-making.

In 1995, Burton developed a framework which outlined the five categories that define how girls know mathematics.

These are:

1. Its person- and cultural/social-relatedness,
2. The aesthetics of mathematical thinking it invokes,
3. Its nurturing of intuition and insight,
4. Its recognition and celebration of different approaches particularly in styles of thinking, and
5. The globality of its applications.

Burton's 1990 work in understanding various international classroom contexts was important because it moved away from the expectation that boys were innately better suited to mathematics and that girls needed to catch up or close a gap. Instead of assuming an innate failure in girls, external factors were identified that could be remedied. In addition, girls were considered to add value to the mathematics classroom, which was an important change from the previous deficit model of assimilation. This understanding informed her 1995 framework to explain how girls ‘know’ mathematics. However, in proposing this model of the way girls know mathematics, it is important to note that Burton has replaced one stereotype for another, albeit one that painted girls and their mathematical capabilities in a more positive light. Nevertheless, Burton’s contribution to the dialogue helped to make mathematics classrooms more inclusive and respectful of the different ways children learn, allowing for different perspectives and a more diverse approach to teaching mathematics. Burton's collection of research painted a picture showing the pedagogy within the classroom was a reflection of societal expectations outside the classroom. Most importantly, it showed that the classroom environment could be altered to be a more encouraging and supportive mathematical environment for both boys and girls.

Internationally, a growing awareness and acknowledgement of gender inequities in the classroom led to a re-imagining of mathematics pedagogy to encourage engagement and participation of girls in mathematics lessons. This was evidenced in 1995, when a consortium was assembled for UNESCO with the underlying question: 'Why are girls and boys experiencing school so differently?' Maths was given special consideration in these discussions. Fennema (1996) contributed to the dialogue and challenged the idea that pedagogical intervention alone could make a substantial enough difference as she had seen no significant change in girls' personal beliefs about mathematics in over 20 years. She cited the small changes in mathematical achievement for girls; however, she noticed the most complex mathematical tasks still showed significant gaps in boys' and girls' achievement. Fennema (1996) also discussed the lack of participation in mathematics as young women were still less likely to select mathematics subjects and therefore limiting their participation in employment that required mathematics. She summarised this by saying that she had come to believe that "females have recognised that mathematics, as currently taught and learned, restricts their lives rather than enriches them" (Fennema, 1996, p. 258). Moving into a new millennium, Rodd and Bartholomew (2006) similarly noted the limited participation and biased classroom environment in their observations of a university mathematics class in England. They noticed a ratio of one female student for every three male students and a distinct 'policing' and discouragement by some male students of the female students' active engagement in class discussions (Rodd & Bartholomew, 2006). While the (male) lecturer invited all students to participate in discussions, it was much less likely for the female students to contribute their ideas or ask questions and also less likely for the lecturer to call on the female students when they did.

2.2.3 The Australian Context

In Australia, the *Girls in Schools Reports* showed that in 1989, the concept of an 'inclusive curriculum' was gaining currency. The report signalled that gender-inclusive practices were being incorporated, particularly into mathematics (McInnis, 1996). In 1992, the National Action Plan for the Education of Girls 1993 – 1997 was endorsed by the Ministers of Education across Australia (Australian Education Council, 1993). This document was to be implemented as a practical manual for teachers to support the education of girls. Changes such as creating classroom environments that allowed for collaboration and cooperation and focused less on competition aimed to ensure girls were in a supportive and engaging environment. At the time, there was a pedagogical shift in focus from equality to equity (Anthony & Walshaw, 2007). Specifically, Anthony and Walshaw (2007) defined *equality* as being about equal outcomes and approaches, while *equity* was viewed as concerning relationships and interactions between contexts and people. Equity is far more nuanced and requires a sensitive educator to pay attention and be responsive to the different needs of the students in their class as an amalgam of their social, cultural and gendered realities (Anthony & Walshaw, 2007). As a result of these more nuanced understandings, educators shifted away from helping females assimilate to the 'norm' and became more concerned with providing agency for girls in the form of a responsive and reflexive classroom environment that was relevant to all learners (Anthony & Walshaw, 2007).

The policy direction changed in 1997 with the report Gender Equity: A Framework for Australian Schools (MCEETYA, 1997). There was a shift from focusing predominantly on girls' education to focusing on both boys' and girls' education, with the underlying premise that equality had been attained (Ailwood & Lingard, 2001). The language in the policy discussed girls' educational disadvantage in past tense and referred to boys and girls as being equally but differently disadvantaged (Ailwood, 2003). However, Vale’s 2002 and 2010 research showed that it could not be said that classrooms reflected the equity that Burton, Fennema and researchers in the 1970s and 80s had advocated for. Vale (2002) showed that mathematics classrooms continued to be male-biased places of learning. Research by Vale (2002) in Australian schools indicated that mathematical classrooms were more likely to be competitive, compared to other disciplines. Vale (2002) asserted this suited the boys who viewed speed and accuracy as indicators of success. The girls in Vale's study reported that they preferred learning engagements in mathematics that allowed them to think through concepts and develop understanding. Vale (2010) further contextualised the lack of progress in classrooms, referring to the 'downstreaming' of gender policy in 1996. She cited continued falling participation rates in mathematics subjects that were minimum requirements for further study and a failure to address continued levels of low self-perception by girls in mathematics. Vale’s research (2002, 2010) demonstrated that inequities in the learning environment that benefited males remained an ongoing problem.

Currently, in Australia, there is still cause for concern as participation rates in mathematics show that girls are much less likely than boys to select mathematics in Years 11 and 12 (the final two years of secondary school) (Figures 2.1 and 2.2). In several states in Australia, mathematics is not compulsory in Years 11 and 12. The culmination of these two years is a ranking system in which students receive an Australian Tertiary Admission Rank (ATAR). This determines students’ entry to university. In addition to requiring a certain ATAR level, many universities require Year 11 and 12 mathematics completion as a condition for enrolment. As Year 11 is the earliest opportunity for students to decide whether they want to continue to learn mathematics, this provides some insight into boys' and girls' attitudes to mathematics and their intentions for university and employment beyond high school. In

Australia, data collected by Wienk and O'Connor at the Australian Mathematical Sciences Institute (2020) showed that girls are under-represented in mathematics courses and that amongst the girls that choose to study mathematics in Years 11 and 12, they are substantially less likely to choose more advanced mathematics courses. Figure 2.1 illustrates the number of students participating in intermediate level maths in Years 11 and 12 in Australia. It is evident that males have had higher rates of participation over the years 2008 - 2019. However, the difference in participation is more noticeable when the information in Figure 2.2 is reviewed. This shows the rate of participation in higher level mathematics. The data indicates that boys have a participation rate at around 13000 students compared to girls' participation of around 8000 students which represents close to 62% boys and 38% girls. These data also show that these participation rates have been consistent from 2008 – 2019.

Figure 2.1

Year 11 and 12 participation rates in intermediate level mathematics in Australia.

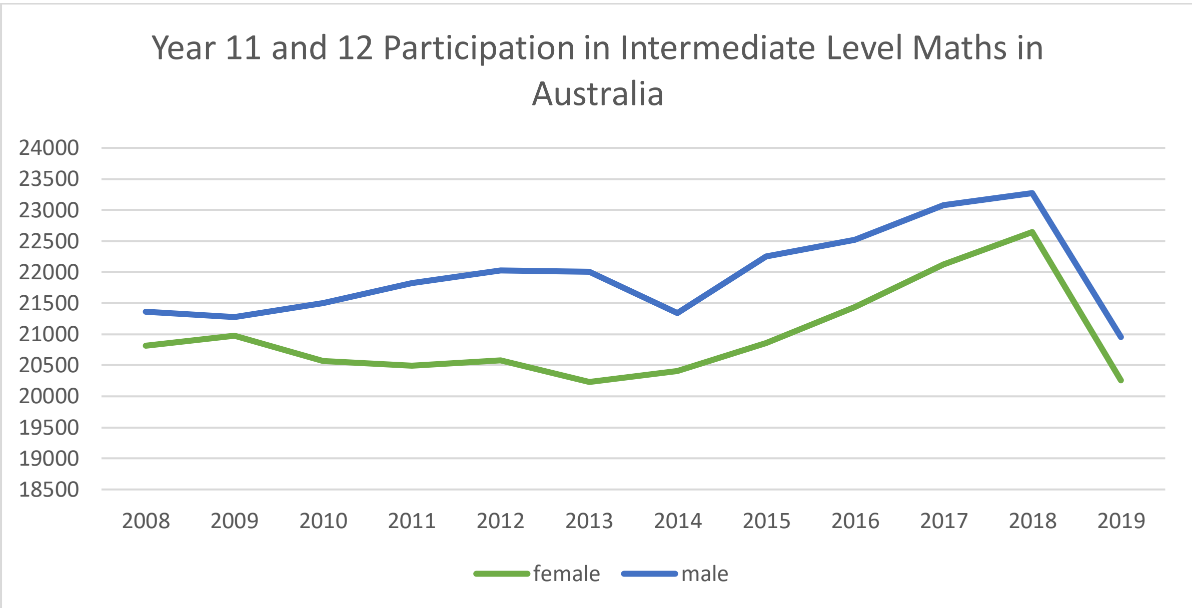
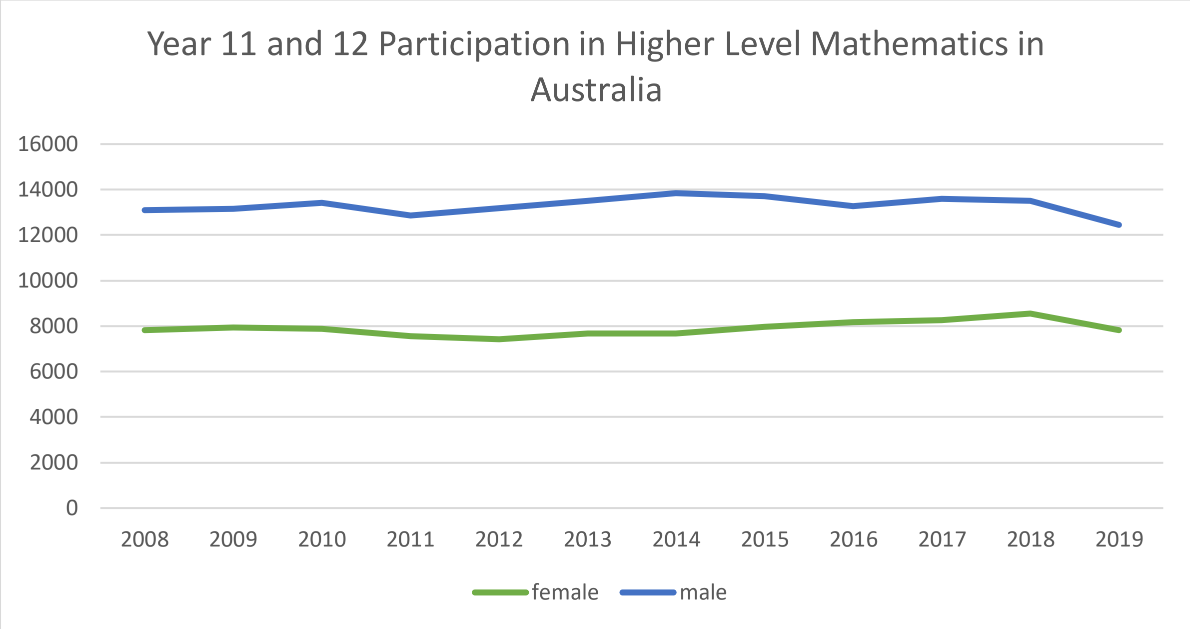


Figure 2.2

Year 11 and 12 participation rates in higher level mathematics in Australia.



2.2.4 The Leaky Pipeline

Based on the participation in mathematics in senior secondary years in Australia by Wienk and O'Connor (2020), the evidence points to a cause for concern for two reasons. First, there is a significant absence of girls, particularly in more advanced mathematics courses. Second, there has not been any real improvement or change to these numbers in the past decade. Prior to these data, Wilson and Mack (2014) reviewed high school mathematics enrolment in Australia from 2001- 2013 and reported a reduction in the number of girls completing higher level maths at the same time as an increasing choice by girls to avoid mathematics entirely. They reported that 27.5% of females took 2-unit maths (higher level) in 2001, however this decreased to 16.3% by 2013. The consequence of this lack of participation of girls and women choosing secondary mathematical courses is that it limits participation in mathematical careers (Kyriacou & Goulding, 2006; Vale, 2008). This disengagement is often referred to as a 'leaky pipeline' as girls make choices throughout school to move away from STEM subjects (Kessels & Hannover, 2007). This metaphor of a leaky pipeline has been used to describe the phenomenon of females slowly trickling away from STEM-related subjects throughout their education (Simpkins & Davis-Kean, 2005).

2.2.5 Mathematics Identity

Thus far, literature has been reviewed over the previous decades for indicators of differences between boys and girls in mathematics education. This has been important to establish that there has been a difference in the perceived relevance of mathematics for boys and girls (Osen, 1974), the ability of boys and girls in the mathematics classroom (Burton, 1990; Fennema, 1974) and a lower participation rate and self-perception of aptitude by girls (Vale, 2010; Wienk & O'Connor, 2020). This literature review will outline the role of identity as a factor. The idea of a 'maths person' will be explored. Who is a 'maths person'? Who thinks they are a 'maths person'? Who is told they are a 'maths person'? Who becomes a 'maths person'? As the literature is reviewed over the coming chapter and these questions of identity are explored, it will become apparent where boys' and girls' mathematical experiences fit and how these contribute to their mathematical identity.

2.3 Who is a 'Maths Person'?

When asked to consider 'who' a maths person is, well-known mathematicians with 'beautiful minds' such as Alan Turing, Albert Einstein, Stephen Hawking and John Nash might spring to mind. Historical accounts of their lives and their important discoveries and contributions to the field portray prodigious geniuses. Hottinger (2016) argued that these portrayals are typically middle to upper class, white and male.

It is important to clarify that the idea that a 'maths person' is a social construct based on the idea that mathematics intelligence and success are inherent characteristics (Boaler, 2015). Leslie et al. (2015) used the term 'field-specific ability beliefs' and suggested that the characteristics associated with mathematicians are that they are 'brilliant' (not necessarily only in mathematics) and that there could even be 'a spark of genius' but that the concept of a 'maths person' is that it involves something innate that is required for mathematical success. When students say they are not a 'maths person', it is an insight into their mathematical identity rather than an accurate indication of their mathematical ability or capacity for learning mathematics. Students who say they are not a 'maths person' may feel that mathematics is outside of their understanding or experiences, and mathematical success for them does not feel attainable (Boaler, 2015). The impact of this thinking is that that when students are asked to complete mathematical tasks, it may feel unnatural and forced, or it could mean that they do not relate to the utility of mathematics or its relevance to the world (Boaler, 2015). Boaler (2015) asserted that the idea that mathematics is only for some people is deeply entrenched in the field of mathematics, much more so than any other discipline. Leslie et al. (2015) conducted a study, surveying 1820 university staff and students in America about their beliefs related to field-specific ability. They were asked to assess the statement: 'Being a top scholar of (their own discipline) requires a special aptitude that just can't be taught' (Leslie et al., 2015, p.262). Out of all the Science, Technology, Engineering, Mathematics (STEM) fields, mathematics was rated the most highly by participants as a field that requires the requisite innate aptitude. The authors then compared participation rates in each field, noting that the higher the expectation of innate aptitude, the lower the participation of both women and African Americans. The idea of the 'maths brain' has been discussed by Boaler (2015) and Leslie et al. (2015). To support their notion that this has no grounding in reality and is simply a social construct as suggested by Boaler (2015), it is worth exploring mathematical achievement in various contexts to see if there is any truth to the idea that either gender is more likely to have an innate aptitude in mathematics.

2.3.1 International Mathematics Achievement

Large scale surveys such as Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) have established that there is no evidence to suggest significant gender differences (Kaiser et al., 2012). In 2009, the Organisation for Economic Co-operation and Development (OECD) reported a slight gender pattern of males outperforming females in all mathematical scales in the PISA assessment, noting that the biggest difference could be seen in the space and shape scale. The other three scales (change and relationships, quantity, and uncertainty) also saw a higher overall achievement favouring boys. However, these were not statistically significant differences, and the mean data did not tell the complete story. Looking at the highest performers amongst students, boys were more likely to reach the top end of the scale, with 17% of males across the OECD achieving the highest two proficiency levels, compared with 12% of females. In contrast, there was a comparable achievement between boys and girls at the lower end of the scale with 21% of males and 22% of females achieving at Level 1 or below.

A meta-analysis of 242 mathematics achievement studies completed between 1990 – 2007 by Lindberg et al. (2010) also established no significant difference between the genders. Lindberg et al. (2010) concluded that their analysis provided "strong evidence of gender similarities in mathematics performance" (p. 1133). Although, their analysis showed one slightly gendered area in high school, they noted slight differences in complex problem-solving in favour of boys. In addition to looking at differences in gender, Lindberg et al. (2010) examined data by problem type and content according to other characteristics, including nationality and ethnicity, which yielded few statistically significant differences in performance. The only characteristics they could determine that were reliable predictors of achievement were age and ability grouping, such as students from academically gifted schools. Finally, and despite the many interventions discussed earlier in this chapter designed to promote girls' mathematical achievement, Lindberg et al. (2010) found no trend over time, between 1990 and 2007, of a decrease in any gender differences reported.

Overwhelmingly though, data from the OECD (2009) and Lindberg et al. (2010) support the idea that there is no reason to expect gender to be a variable that can predict significant mathematics achievement differences.

2.3.2 Australian Mathematics Achievement

A study by Vale (2008) reported that when Australian TIMSS and PISA results and large-scale studies such as the Australian-based Early Years Numeracy Research Project (EYNRP) were analysed, there were no significant differences in mean scores for mathematics between the genders. An analysis of the TIMSS data focusing on the Australian context by Lee and Anderson (2015) showed no significant gender differences in students' mathematics results in the Year 8 exam. It was also noted that there were no significant gender differences found within any single state or territory in Australia (Lee & Anderson, 2015).

However, there were some notable observations in different contexts and content. Nine-year-old girls in Australia received higher average scores for the geometry items on TIMSS than nine-year-old boys (Thomson & Fleming, 2004). In the secondary school years, it was reported that on average 13-year-old Australian boys performed better than girls on number and measurement items in the TIMSS 2002 - 2003 while 15-year-old Australian boys performed better than girls on space and shape and uncertainty items in the 2003 PISA study (Thomson & Fleming, 2004). Vale (2008) reported that Australian girls tended to perform better in the primary school years, whereas boys performed better in the secondary years.

While it is pertinent to note the differences that have been reported in these large-scale studies, it is important to remember that differences between the genders were not significant. That is, that gender was not a reliable predictor of achievement in mathematics. In answering the question, who is a 'maths person'? the achievement results reviewed showed no significant gendered differences and no reason for either boys or girls to distinguish that they have any inherent mathematical advantage over the other gender.

2.3.3 Neuroscience Research and Gender Essentialism

The study of the brain's structure indicates that there are more similarities than differences between male and female brains (Joel et al., 2015). In fact, Joel et al. (2015) suggest that there is not much utility in describing male or female brains in such a binary way. Their study of 1400 MRIs of human brains showed that a dimorphic view of brain structure is a misnomer and suggests instead that brains more closely resemble mosaics of behavioural characteristics (Joel et al., 2015). Importantly, Joel et al. (2015) also noted that they did not find anything to indicate that a behavioural characteristic would be likely to be more 'male' or 'female'.

Hines (2020) reviewed the field of neuroscience in relation to gender and said that 'exciting' discoveries in the 1950s and 1960s supporting the idea of a male or female brain had more to do with a desire to explain behaviour than a true finding that there is such a thing. She also pointed to her earlier research in 2015 demonstrating young children's interaction with toys. Her findings showed that boys were more likely to choose toys more typically considered male, such as trucks. Girls were more likely to select dolls (Hines, 2015). However, in her 2020 review of the field of neuroscience, she considered that while her earlier findings indicated that testosterone influenced the play behaviour of children, there were other social factors that might encourage and consolidate this play such as parents and peers rewarding the behaviour they considered gender appropriate (Hines, 2020).

Rippon et al. (2021) noted that historically within neuroscience research, there have been several problems with the way researchers have reported findings. Rippon et al. (2021) reviewed a number of studies to show that researchers have been inordinately focused on finding gender differences and are more likely to use hyperbolic language to describe statistically insignificant findings than in other scientific fields. Rippon et al. (2021) categorised the number of times words like 'many' and 'strong' were used to describe marginal findings. They pointed towards an approach that lacked a nuanced understanding that 'gender' is not just made up of biological differences but also psychosocial influences (Rippon et al., 2021). Rippon et al. (2021) also acknowledged that there was still a limited understanding between structure and function of the brain which can create an opportunity to speculate and generalise.

The idea of a male or female brain is explained by the idea of gender essentialism. Meyer and Gelman (2016) describe that essentialism is a set of lay beliefs regarding categories that are innate or arising in nature as an 'essence'. Social categories, including gender are also condensed to a set of beliefs that become commonly held such as 'women are better with language and multitasking' or 'men are better at logic and spatial awareness' and that these characteristics stem from an inborn, causal force (Meyer & Gelman, 2016). To understand the gender essentialist beliefs of a group of parents (n=80) and children aged 5 – 7 years (n=80), Meyer and Gelman (2016) asked each participant to imagine a desert island where an infant was being raised exclusively by members of one gender. They were asked to describe behaviours and characteristics such as the types of activities they would play and the toys they might choose. Responses were evaluated as a score from 0 to 1 as to how much the participant agreed with stereotypical gender characteristics. For example, a boy would play with hammers and nails and a girl would play with dolls. Meyer and Gelman (2016) found that both parents and children demonstrated gender essentialism (at varying rates) and that if a parent's score was higher then there was also a positive correlation with their child having a higher score. In addition, these beliefs predicted the skills, activities and occupations that the participants expected each gender to pursue.

Research into neuroscience has not demonstrated that there is any support for the idea of the male or female brain (Rippon et al., 2021). However, there is support for the idea that both men and women develop a narrative based on categorised behaviours as innate characteristics of each gender, and that these influence beliefs about capabilities, interests and vocations (Meyer & Gelman, 2016). In addition, as part of the process of socialisation, children learn about gender essentialist characteristics and begin to associate males and females with different capabilities, interests and vocations whether they are accurate or not (Meyer & Gelman, 2016).

2.4 Who Thinks They Are a 'Maths Person'?

This section deals with the beliefs and attitudes of individuals. There have been a variety of terms used in the research explored thus far and so at this point, it becomes important to contextualise and define these terms. Amongst education researchers, there is some flexibility within commonly used terms such as 'attitude' and 'belief' (Leder, 2019b). Pajares (1992) claimed that within the field of educational psychology "defining beliefs is a best a game of player's choice. They travel in disguise and often under alias – attitudes, values, judgements, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions… to name but a few.” (Pajares, 1992, p.309). Daskalogianni and Simpson (2000) have suggested that in the absence of well-defined conceptual understandings across mathematical research literature, that the appropriate step is to develop a functional definition that is suitable for the research in question. In light of this, the conceptual definitions below will be utilised. The following three terms will be used to define the broad range of perspectives that students may have in relation to mathematics: self-concept, self-efficacy and emotions. These three terms were selected as they are considered by the researcher to be well-understood and are also helpful as broad categories to be inclusive of other themes that arise in literature such as mathematics anxiety, confidence or perceived ability to problem solve.

Self-concept relates to self-perceptions about personal abilities and competencies that aid mathematical success (Pintrich & Schunk, 2002). Niepel et al. (2019) expanded this definition from a focus on the self, to include the influences on self-concept from external factors. They defined mathematical self-concept as “a person’s self-perception in mathematics… shaped by one’s experience with the environment and significant others.” (Niepel et al., 2019, p. 1120). In defining mathematical self-concept in this way, they reinforced the importance of social learning and the environment on self-concept which earlier researchers like Pintrich and Schunk (2002) had not considered. An example of self-concept can be seen in the statement 'I'm good at maths'.

Self-efficacy is a belief in personal capabilities to complete a task successfully (Bandura, 2012). An example of self-efficacy in mathematics could be a student who thinks, 'I can work this maths problem out'. Emotions about mathematics also play an important role because they influence self-concept and self-efficacy (Kim & Pekrun, 2014). An example of this is 'I love maths!'

In the following section, the literature on mathematics self-concept, self-efficacy and emotions about mathematics will be reviewed to see if there is a distinguishable difference between the way boys and girls think about themselves in relation to mathematics and whether either group considers themselves to be more or less of a 'maths person'. To understand the way students think about their mathematical identity, research that has used self-reporting tools will be reviewed to see what girls and boys are constructing and relaying about themselves and mathematics.

2.4.1 How Do Students Rate Themselves in their Self-concept, Self-efficacy and Emotional Responses to Mathematics?

Prior to the 1980s, there was little attention paid to affective aspects of mathematical behaviour (Di Martino & Zan, 2010). The seminal book published in the late 1980s titled *Affect and Mathematical Problem Solving* (edited by McLeod and Adams, 1989) encouraged mathematics researchers to consider students' behaviour *internal* to mathematics activities (Di Martino & Zan, 2010). In one of the chapters of McLeod and Adam's book (1989), Mandler poses some uniquely worded questions regarding aversion to mathematics "When in a child's school life do the first signs of aversion to mathematics appear? How are these signs first expressed in a learning situation? And how (does) the curiosity machine turn into a mathematical idiot?" (Mandler, 1989, p.240). The questions posed by Mandler (1989) are attempting to get to the internal workings and beliefs held by mathematics students. The questions Mandler asked implies that these beliefs are connected to and responsible for mathematical behaviours.

Self-reported data can provide useful insights into students' relationship with mathematics. Vale (2008) compiled a meta-analysis of student responses relating to statements about affect and mathematics. This meta-analysis included TIMSS and PISA data in addition to large-scale studies from Australia and New Zealand. These assessments collected data on students' self-reported affective traits including self-confidence, interest, enjoyment, self-efficacy, self-concept and anxiety. In a large-scale study completed by Watt in 2005 on Year 10 students, boys were found to have significantly higher mean scores in self-perception, expectation of success and the intrinsic value of mathematics. Similarly, when Vale (2008) compared the overall mean results for Australian students in TIMSS (Years 4 and 8) and PISA (15-year-olds), boys also showed significantly higher mean results for self-confidence, self-efficacy, and self-concept within each age group. They also had higher mean results in enjoyment, although it was not significantly different to the girls. Within the data that Vale (2008) analysed, there was only one category in which boys had a lower mean result, which was anxiety. The large scale and age range of these data made these findings both important and concerning as girls were shown to be significantly less likely to view the utility of mathematics or their capability within mathematics (Vale, 2008).

The 2012 PISA results were a particularly insightful year for mathematics researchers. While the PISA assessments are conducted on a three-yearly cycle and measure various learning areas, each PISA has a particular focus. For example, it has been reading in one cycle and financial literacy in another. The 2012 PISA focused on mathematics, and so it is the most relevant to examine to better understand results from the past decade. PISA results measured students' mathematical achievement as well as intrinsic motivation. Intrinsic motivation was measured as a summary of students' responses to four statements relating to interest and enjoyment. These were:

- I enjoy reading about mathematics
- I look forward to my mathematics lessons
- I do mathematics because I enjoy it
- I am interested in the things I learn in mathematics.

Analysis of the 2012 PISA data by Thomson et al. (2013) showed that of the 510,000 15-year-old students surveyed across all 65 countries, males had a significantly higher self-reported level of intrinsic motivation towards mathematics than females. Thomson et al. (2013) also noted that Australian females' intrinsic motivation was lower than the OECD average while Australian males rated themselves more highly than the OECD average in all four statements. These self-reported scores are relevant to achievement as the 2012 PISA data show that those who report a higher level of intrinsic self-motivation also have a higher achievement level in mathematical literacy (OECD, 2013).

There are also other connections to affective characteristics and mathematical achievement. For example, Pinxten et al. (2014) established a relationship between mathematical enjoyment and feeling mathematically competent and reported that the two constructs were often correlated. In addition, these factors can be linked to mathematical achievement. In a longitudinal study of 4724 Belgian students in Years 3 - 7, Pinxten et al. (2014) attempted to distinguish between enjoyment and feelings of competence to see which variable more strongly determined mathematical achievement. Their results showed that both mathematics enjoyment and mathematics competence beliefs are strong predictors of mathematics achievement. They also found that the relationship between perceptions of mathematical competence and mathematical achievement (0.47 – 0.60) were more than twice that of the relationship between enjoyment and mathematical achievement (0.17 – 0.29). Additionally, Pinxten et al. (2014) found that boys reported higher levels of mathematics enjoyment and mathematics competence than girls. This perception (whether it is accurate or not) implies that boys are also more likely to consider themselves a ‘maths person’.

2.4.2 Who Thinks They Are Not a ‘Maths Person’?

To fully consider who thinks they are a 'maths person', understanding the opposite characteristics can elucidate the concept of a 'maths person' more completely. A student suffering from mathematics anxiety almost certainly thinks they are not a 'maths person'. As previously shown in the literature, an examination of the characteristics of self-concept, self-efficacy and emotions relating to mathematics show that boys have significantly more positive views of their mathematical capabilities than girls (Pinxten et al., 2014; Thomson et al., 2013; Vale, 2008). Vale's meta-analysis in 2008 discussed earlier showed that the only characteristic that girls related to in mathematics more substantially than boys was anxiety; therefore the role that anxiety plays as students develop their mathematical identities requires further attention.

Mendick's 2006 development of mathematical identity pairing binary opposite characteristics is a useful lens through which to view the way boys and girls can begin to understand how they fit into the mathematical sphere. Mendick (2006) observed 42 students in their mid to late teens who were completing high level mathematics courses. She sat in on classes to listen to the way students discussed mathematics and their own capabilities. Mendick (2006) then interviewed five of the students in the top class made up of 19 students. Only two students were female so she specifically asked for an interview to get their responses and three boys had volunteered to participate. The gender imbalance in the classroom is regrettable for a research study but also provides information on ‘who thinks they are not a maths person’. By analysing the observations from classes and transcripts of the five interviews, Mendick developed what she called a ‘narrative of self’ of what students considered characteristics that were essential to mathematical success. She particularly focused on the way students spoke about their own identity and their personal beliefs about their efficacy and capability in mathematics. Mendick (2006) grouped the students together who identified as being ‘good at maths’ compared to ‘not being good at maths’ and identified frequent terms used and patterns of discourse. She claimed that the characteristics that students viewed as valuable to being a mathematician were more closely aligned to the characteristics they also considered male. Central to this notion was that cleverness is essential to mathematics as opposed to effort. In fact, acknowledging that effort was required was seen as antithetical to being a good mathematician (Mendick, 2006). One of the top students who was interviewed claimed that she would not possibly get into the university course she was interested in because “some people are really, really clever… and I’m me”. (Mendick, 2006, p.212). The two girls denied that they were clever and instead emphasised the ways in which they did not feel clever. One attributed her success to a very patient tutor, the other side-stepped the idea that she could be clever and instead discussed a boy in her class who was 'really clever'. The girls in the study emphasised the ways in which they had to work hard, whereas the boys who considered themselves ‘good at maths’ took pride in having an authentic intelligence that did not require the determination and struggle that they felt other students appeared to require.

One of the interesting features of this research is how separated from reality many of the students’ self-concepts were. The student participants were in the top mathematics courses and receiving excellent grades and yet only four out of the 19 students felt comfortable to say that they were ‘good at maths’. All four were male. This in itself does not make a case for a gendered response in this study, given there were many males that also considered they were ‘not good at maths’. Also, the sample size is quite small and is only one case. However, the general characteristics compiled by Mendick do provide some insight into the way both boys and girls view mathematical traits and characteristics of ‘maleness’ or ‘femaleness’. Mendick (2006) asserted that male characteristics were considered more valuable than their binary opposite which is more likely to be considered less valuable and a female trait. In addition, this perception becomes a boundary for girls as they engage in mathematics. Mendick (2006) included a non-exhaustive list of the binary opposites noted in her findings. In each pair, characteristics considered male can be seen on the left compared with those perceived as female on the right.

- Maths people/non-maths people
- Mathematics and sciences/languages and arts
- Ordered and rule-based/creative and emotional
- Numbers/words
- Thinking/writing
- Fast/slow
- Competitive/collaborative
- Independent/dependent
- Active/passive.
- Dynamic/static.
- Naturally able/hard-working.

- Real understanding/rote learning.
- Reason/calculation.
- Reasonable/calculating.
- Really good at maths/good at maths (Mendick, 2006, p.212).

2.4.3 Mathematics Anxiety

Mathematics anxiety is a psychological factor that can damage self-concept and cause disengagement in mathematics (Stoet et al., 2016). The origins of mathematics anxiety as a concept go as far back as 1954 when a classroom teacher, Mary Fides Gough, introduced the term mathemaphobia, explaining that it was a disease as prevalent as the common cold (Gough, 1954). Continuing with the analogy of mathematics anxiety as a disease, Gough stated that it could be transmitted from student to student and prove fatal to any kind of mathematical success. Gough noticed that it seemed to affect her female students more, with the result being a lesser ability to learn. Wilson and Gurney (2011) defined mathematics anxiety as "a learned emotional response, characterised by a feeling that mathematics cannot make sense, of helplessness, tension, and lack of control over one's learning" (p.805). Harding et al. (2006) defined mathematics anxiety as a "learned emotional response which usually comes from negative experiences in working with teachers, tutors, classmates, parents or siblings" (p.2). Mathematics anxiety is a well-researched concept, with the consequence of the anxiety considered to be mathematics avoidance (Ashcraft, 2002). The impact is then compounded as avoidance generally leads to worse results, fuelling further anxiety.

A neuroimaging study conducted by Harms (2012) has shown that a learned fear response distinguishes mathematics anxiety. This fear response is the equivalent of the anticipation of physical harm (Harms, 2012). A mathematical problem or even the thought of having to complete a mathematical problem is enough to trigger this response (Young et al., 2012). Given the neurological impact that mathematics anxiety has on sufferers, it is reasonable to assume that these students would choose to avoid mathematics. Therefore, students who experience mathematics anxiety are unlikely to be able to achieve their potential. Since it is well-established that girls and women report greater mathematics anxiety than boys and men, and that girls are frequently less confident and more likely to suffer from mathematics anxiety (Ashcraft & Ridley, 2005), it is unsurprising that girls are less likely to participate in mathematics.

It is evident that the way that boys are girls develop their self-concept, self-efficacy and emotional response to mathematics has been different and while boys have developed a healthy mathematical identity, girls have found it challenging to do the same.

2.4.4 Why Thinking You Are a 'Maths Person' Matters

Dweck (2008) suggested that everyone has a mindset or a core belief about how they learn. She asserted that when people change their mindsets, it can change the trajectory of their learning. She claimed that if a student determines they are not a 'maths person' it allows them to stop persevering with mathematics, seeing it as impossible to achieve success without the inherent capability that they perceive other students to possess (Dweck, 2008). This construct is also unhelpful as it implies that if there is struggle, then a student may not fit the criteria of being a 'maths person' which may also lead to disengagement.

Walkerdine (1990) proposed the idea that thinking you are good at mathematics has no grounding in reality. Rather, it is more to do with the way students construct their identity. She posited that rationality and masculinity are associated together, so boys and young men are comfortable considering themselves as good at mathematics. Whereas for girls, mathematical excellence is antithetical to femininity (Walkerdine, 1990).

Gjovik et al. (2022) synthesised the thoughts of Dweck (2008) and Walkerdine (1990) when they discussed the role of stereotype and identity. They endorsed the perspective put forward by Walkerdine (1990) that personal views about aptitude in mathematics are not necessarily grounded in reality, in their discussion of the difference between stereotypes and beliefs. They claimed that stereotypes were a subset of beliefs and described beliefs as views that people think "are objectively true or false" (Gjovik et al, 2022, p.3). However, stereotypes form part of this tapestry of beliefs and as Walkerdine (1990) has suggested can be based on a false narrative. Gjovik et al. (2022) have demonstrated the subjectivity of these views by asking 767 Norwegian pre-service teachers to draw a picture of a mathematics teacher. The stereotypical mathematics teacher as depicted by these students was male, with glasses and a checked shirt, usually with a beard and balding. This is a clear stereotype and while some mathematics teachers may look like this, it is not necessarily accurate or representative of all mathematics teachers. Interestingly, the students in this study also acknowledged that it was not likely that mathematics teachers would all look like this, demonstrating that these participants can hold contrasting beliefs simultaneously. In 1935, Katz and Braly defined stereotype as "a fixed impression, which conforms very little to the facts it pretends to represent." (1935, p.181).

The reason that this is important to the present study is that it demonstrates stereotype as a component of personal beliefs. A consequence of a personal belief is that it has the power to influence decisions about where to expend energy and effort. If a pre-service teacher in Norway is not male, or without a beard and receding hairline, then Gjovik et al. (2022) suggested that it is less likely they will select mathematics as a specialisation. This is not connected to a lack of talent or interest but due to a lack of representation and ability to see that they can fit into that space. Where Walkerdine (1990) has defined personal beliefs as subjective, Dweck (2008) has been pragmatic and intentionally considered that if people already think about their ability in a subjective manner, given there is a choice, then it may as well be positive. Studies by Spencer et al. (1999) on 'stereotype threat' and 'stereotype lift' demonstrate that the power of suggestion and stereotype have an impact on academic success. Spencer et al. (1999) showed that when students were told that their gender had performed poorly on a mathematics test in the past, consequently that gender underperforms. Conversely when participants were told both men and women performed equally well in the mathematics test in the past, the results of the participants were roughly equal. Walton and Cohen (2003) built on this idea by looking at the idea of 'stereotype lift'. By providing a negative stereotype about another group, they demonstrated that participants would perform better than when there was no negative stereotype provided. The research from Spencer et al. (1999), Walton and Cohen (2003) and Gjovik et al. (2022) indicated that stereotypes can be powerful and persuasive.

2.4.5 Building a Conceptual Model of Mathematical Identity

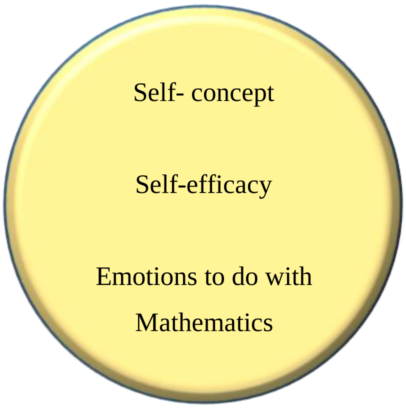
A meta-analysis collated by McLeod and Adams in 1989 encouraged researchers to understand and explore internal mathematical behaviours (Di Martino & Zan, 2010). Understanding affective factors related to mathematics increased in importance to the mathematics researcher in the late 1980s and so, formed an essential part of this literature review. These affective factors, if understood well, could attempt to respond to Mandler's provocative set of questions "When in a child's school life do the first signs of aversion to mathematics appear? How are these signs first expressed in a learning situation? And how (does) the curiosity machine turn into a mathematical idiot?" (Mandler, 1989, p.240).

Three decades later, mathematics researchers were still considering the role of affective factors in mathematics education. This was evidenced by the 2016 International Congress on Mathematics Education (ICME) held in Hamburg where 3500 participants from 105 countries met to discuss 'the heart of the congress'. Among the topics considered were 'affects, beliefs and identity in mathematics education' culminating in the book *Affect and Mathematics Education* edited by Hannula et al. (2019). Following the lead of these researchers, this present study also places affective factors at 'the heart' of understanding the complexities of students' mathematical attitudes.

Three affective factors have been visualised conceptually as a series of concentric circles beginning with the internal components in Figure 2.3 of students' affective factors. The terms 'self-concept', 'self-efficacy' and 'emotions to do with mathematics' were selected to define the way that students consider who they are as mathematics learners. As this chapter progresses, further components will be added and built into this model so that a visual representation of mathematical identity can be envisaged at each level.

Figure 2.3

Conceptual Framework: The internal components of students' mathematical identity



2.5 Who is Told They Are a 'Maths Person'?

To this point, this literature review has established that boys and girls cannot reliably determine their mathematical ability based on their achievement and results in mathematics (Dweck, 2008; Gjovik et al., 2022). However, the literature has also pointed towards the development of very different mathematical identities for boys and girls (Mendick, 2006). If there is no innate or intrinsic reason for this view, then it is important to look closely at the learning environment that students inhabit and establish the messages they receive about their mathematical potential. In this section, the role of parents, teachers and peers are explored to see what those closest to the students believe and expect about gender and mathematics. In addition, cultural messages and the media narrative are identified to determine what young boys and girls hear about their gender and mathematics, and how they fit into the cultural construct of who is and can be a mathematician.

2.5.1 Messages About Mathematical Ability from Parents

Understanding parents' beliefs and expectations about the capabilities of their children based on their gender explains some of the messages that children receive in their early years. In 2014, Stephens-Davidowitz conducted a large-scale analysis of Google search information and found that American parents were 2.4 times more likely to ask Google if their son was gifted compared to their daughter. Stephens-Davidowitz' (2014) study also reported that sons were much more significantly represented in all questions related to searches about intelligence. Conversely, when the phrase "is my daughter…." typed into google, the most common adjective used to complete the sentence was "overweight". This question was asked almost twice as regularly for daughters as it was for sons. Stephens-Davidowitz (2014) also found that parents were 1.5 times more likely to wonder whether their daughters were attractive compared to their sons and three times more likely to speculate on how ugly their daughters were compared to their sons. Stephens-Davidowitz found no significant relationship between the quantity of these types of gender biased questions and the political or cultural make-up of the U.S. state the questions came from. The author also found that these stereotypes had not decreased since 2004 when Google began its search engine. Given the perceived anonymity of online search results, it could be said that this is an unvarnished and accurate insight into parents' true beliefs about gender, which might be downplayed during research surveys and interviews. Nederhof (1985) stated that social desirability bias is one of the most common sources of bias affecting the validity of research findings. Exploring Google data is a novel way to collect large-scale information and to mitigate this bias. While these results do not specifically relate to mathematics, they demonstrate that parents have different expectations for their children based on their gender and that these views are consistent over time and not necessarily impacted by ideological beliefs such as political persuasion.

Eccles et al. (1990) demonstrated that mothers with stereotypical beliefs about males being inherently more talented in mathematics transfer this belief to their own children. That is, their daughters are less likely to achieve in mathematics than their sons. Eccles et al. (1990) found that by Year 6, mothers had higher expectations for their son's mathematics achievement than their daughter's. They found that this was only in the cases where the mothers also believed that males had a natural advantage in mathematics. Mothers who thought boys and girls were equally as likely to be capable mathematicians, made statements about their children's ability that supported this. That is, their daughters were just as likely to achieve in mathematics as their sons. Gunderson et al. (2012) proposed that through the process of socialisation, parents can influence students' beliefs and emotional engagement with a subject. Importantly, parents also have a role in continuing this stereotype. Tomasetto et al. (2015) built on the findings from Eccles et al. (1990) as they explored the relationship between both parents and their 6-year-old children in a study of 285 families in Italy. Parents were asked to rate their child's mathematical ability and the children were asked to rate their own ability. Their findings showed that children mostly had a positive self-perception of their ability. However, where differences showed that they had a lesser self-belief, the children's negative self-view was related to the parents' view. In addition to the importance of this result in understanding the way stereotypes are passed on, this is one of the very few studies to identify the impact of stereotypes on children as young as six years old.

Further to the literature already discussed in this section (Eccles et al., 1990; Gunderson et al., 2012; Tomasetto et al., 2015) showing that parents hold stereotypical beliefs, Stoet et al. (2016) provided additional insight showing that children in their study absorbed these stereotypical messages and used them to inform their own self-concepts. Stoet et al. (2016) reported that parental expectations significantly impacted the development of mathematics anxiety in their children. In their study across 68 countries, girls reported that their parents found mathematics less important than boys did. In a subset of 11 countries within this study, Stoet et al. (2016) reported that parents of girls evaluated mathematics as less important than parents of boys. Furthermore, Stoet et al. (2016) found a correlation between students' perceptions of their parents’ valuation of mathematics and mathematics anxiety. The study indicated that, the larger the difference in boys' and girls' perception of their parents' value of mathematics, the more likely girls would experience higher rates of mathematics anxiety than their male counterparts.

In 2015, Maloney et al., demonstrated the way in which these self-concepts regarding mathematics can be transmitted from parent to child in first and second grade. The study examined 438 students from 29 public and private schools in the U.S. for their mathematics ability as well as mathematics anxiety level. They also assessed their parents' mathematics anxiety. From this, it was found that parents who were identified as 'mathematics-anxious' had a significant effect on their child's progress – causing them to slip a third of a year level behind in mathematics. This only occurred if the parent attempted to help their child regularly with homework. However, if mathematics-anxious parents did not help with homework much or at all, their children achieved better results than those who had mathematics-anxious parents helping them. Presumably, because they were not spending time on mathematics with their child, there was no transmission of anxiety and therefore no effect on their child's mathematics achievement. It is interesting to speculate on the messages given from parent to child during the homework help sessions that would have this impact. Maloney et al. (2015) described parents as well-intentioned, although they lacked awareness of their own mathematics anxiety and its impact. Messages such as "I'm not a maths person either, that's o.k." are intended to be comforting, but transmit the message that the child can opt-out themselves and that being a 'mathematics person' is not an essential or relevant characteristic (Hoffman, 2015). The relevance of mathematics is often downplayed, particularly by parents attempting to provide solace to their children when they find mathematics difficult.

A 2015 TIMSS analysis of Year 4 students completed by Mejia-Rodriguez et al. (2021), showed that both children and their parents were more likely to think girls would have a lesser self-concept in mathematics than boys. Interestingly, for the first time, the 2015 TIMSS results also included a survey for parents. The analysis of this showed that parents who had higher expectations for their children (regardless of gender) and spent time with their child in early numeracy activities had a positive impact. It is reasonable to consider then that if parents have lower mathematical expectations and spend less time participating in numeracy activities with their daughters than they do with their sons, this could impact their daughter's self-concept. Mejia-Rodriguez et al. (2021) suggested that the poor self-concept demonstrated by Year 4 girls globally required further research to see when girls start to lag behind regarding their mathematical self-concept. This present study intends to explore the mathematical self-concept of students when they begin school, aged 5 to further develop the body of knowledge.

In a longitudinal study of 2602 Australian mothers by Parker et al. (2021), mothers were asked to describe their child's progress in mathematics and reading compared to their classmates. This survey was repeated when their child was in Years 3, 5 and 7 and then compared to their standardised test results from the National Assessment Program – Literacy and Numeracy (NAPLAN). Gender was a consistent predictor of maternal judgements, with mothers being significantly more likely to say their son was 'better' or 'much better' than classmates in mathematics. Daughters were considered 'better' or 'much better' than their classmates in reading. This study shows that gender stereotyping in mathematics (and reading) remains a current issue (Parker et al., 2021). The results from this study focus on children from

Year 3 (about age 8). It would be interesting to see if the maternal views described in this article were apparent for younger children. That is, have maternal views been consistent throughout the child's school years, including the formative early years?

Sanctioning beliefs that mathematics is difficult and unimportant, fuel existing negative attitudes. To emphasise the inappropriateness of this concept, consider the contrast of telling a child it is "o.k. to not be a reading person". Petra Bonfert-Taylor, a professor of engineering at Dartmouth college, expressed this idea when she said "We (parents) are perpetuating damaging myths by telling ourselves a few untruths: math is inherently hard, only geniuses understand it, we never liked math in the first place and nobody needs math anyway" (Bonfert-Taylor, 2016, para. 3).

If this is the message that is being transmitted to children, it is not an unreasonable assumption to make that there is a connection between these demotivating beliefs and the development of a concept that mathematics is not relevant. Further, if this message is being transmitted more to girls than to boys, it becomes clearer how the beginning of the 'leaky pipeline' forms, as girls begin to establish their mathematical identity. If mathematics is not relevant, then there is no need to persist when it gets difficult. There is a ready-made excuse, endorsed by parents to devalue and withdraw from mathematics (Bonfert-Taylor, 2016).

Gender-stereotyping in mathematics is particularly important as it is interconnected with students' self-concept and self-efficacy. Kaiser et al. (2012, p. 146) claimed that "the gender stereotypical perceptions of mathematics are so deeply rooted in the students' minds that the students… include them into their self-perception." When parents de-prioritise their daughters' mathematical intelligence, girls are less likely to believe they are capable of mathematical success (Stoet et al., 2016). Bandura (1986) noted that if students' inherent beliefs about themselves are diminished, this sense of incapability of attainment leads them to "forsake the endeavor, and their beliefs about the outcomes such accomplishments could bring have little effect on their behavior" (1986, p. 220).

2.5.2 Messages About Mathematical Ability from Teachers and Peers

The literature has illustrated that there are some stereotypical views from parents regarding gender and mathematics (Mejia-Rodriguez et al., 2021; Stoet et al., 2016). However, to understand the messages children receive more fully, the literature has also been reviewed to understand the beliefs of teachers and peers.

Thirty-eight first-grade teachers in a U.S. study were asked to identify their two most and least successful boys and girls in mathematics and attribute causes for their success or failure (Fennema et al., 1990). Interestingly, when given free choice to select the top student, males were chosen 79% of the time. The study found that teachers incorrectly identified their top students and attributed their male students' success to ability, whereas the top girls were perceived as hard-working. The teachers also thought that the factors that distinguished their top boys from girls were that boys were more competitive, logical, adventurous, contributed answers more frequently, enjoyed mathematics more and were more independent. In 2000, Tiedemann conducted a similar study on 52 third and fourth-grade teachers in Germany to understand their perceptions of mathematical ability according to the gender of their students. He found that teachers rated mathematics as more difficult for average achieving girls than average achieving boys. Within the group of average achievers, teachers nominated the girls as less logical than the boys. Girls were thought to require more effort to make mathematical gains than the boys. When students failed, the teachers attributed the failure more so to lack of ability for the girls than the boys. Both Fennema et al. (1990) and Tiedemann's (2000) results demonstrate that teachers hold stereotypical beliefs about their students based on gender. These beliefs impacted their expectations of their students' achievement and contribution in the classroom. This requires further investigation and is part of the rationale for including teachers as participants in the present study.

A study by Fantuzzo et al. in 2007 in Australia showed that self-regulation was a good predictor of mathematical competence. Behavioural self-regulation includes cognitive skills such as inhibitory control, as well as the ability to work independently, listen and follow directions (Fantuzzo et al., 2007). Ponitz et al. (2009) concur that self-regulation is a good predictor of mathematics achievement. They observed students and collected teacher ratings to confirm that students with the ability to self-regulate were usually higher achievers in mathematics. Their study also showed that teachers were quite accurate when rating students on their ability to self-regulate (Ponitz et al., 2009). Fantuzzo et al. (2007) found that girls were more likely to display self-regulatory behaviours than boys and display self-regulatory and positive learning behaviours more broadly. When the findings from Fennema et al. (1990) and Tiedemann (2000) are compared to the findings from Fantuzzo et al. (2007) and Ponitz et al. (2009) it is interesting to note that despite the positive correlation between higher levels of self-regulation and mathematics competence (Fantuzzo., 2007; Ponitz., 2009), which was found more likely to be a characteristic of girls (Fantuzzo., 2007), that teachers still nominated boys to be more mathematically competent (Fennema et al., 1990; Tiedemann., 2000). Teacher's expectations in these studies showed that they expected that girls would be well-behaved and diligent in class, Fantuzzo et al. (2007) support this notion. However, teachers were not necessarily acknowledging mathematical achievement in girls, believing it to be a by-product of positive learning behaviours rather than innate talent (Fennema et al., 1990; Tiedemann., 2000). The implication is that teachers appear to be less likely to value mathematical competence if they perceive it is attained through diligence rather than innate talent.

Heyder et al. (2020) proposed the idea that teachers' beliefs about innate ability can predict the classroom environment they create for students. That is, whether it is supportive or discouraging for their students. In addition, Heyder et al. (2020) asserted that the classroom environment matters for children's motivation. They considered it important as intrinsic motivation predicts participation in mathematics throughout school and in later life (Heyder et al., 2020). In a study of 837 4^{th} grade students in Germany and their teachers, Heyder et al. (2020) analysed responses from teachers showing whether they thought mathematical aptitude was innate, and how this related to students' feelings of mathematical competence. Their results showed that the students achieving in the lower 30% of participants tended to evaluate their mathematical competency lower if they had a teacher who had fixed beliefs of mathematics as an innate skill, compared to students in the same cohort who had teachers that believed mathematical ability could be developed (Heyder et al., 2020).

Beilock et al. (2010) have also examined the impact of teachers' mathematics anxiety on their students. Their study investigated 117 early elementary (Years 1 and 2) students' mathematics achievement in the first three months of the school year and again in the last two months of that year. At both the beginning and end of the year, children were read two gender-neutral stories about a student who is good at mathematics and a student who is good at reading. They were then asked to draw those students. Notably, female students who confirmed traditional gendered beliefs and drew a boy mathematician and girl reader also had a significantly lower mathematics achievement than boys by the end of the year. At the beginning of the school year, there was no significant relationship between the female teachers' mathematics anxiety and students' mathematics achievement (girls: $r=-0.13$, $p=0.31$; boys: $r=0.12$, $p=0.40$). However, by the end of the school year, the higher the female teacher's mathematics anxiety, the lower was the girls' mathematics achievement ($r=-0.28$, $p=0.022$) but not the boys' ($r=-0.04$, $p=0.81$). This research highlighted that female teachers with gendered views and mathematics anxiety can not only transmit this anxiety to their female students in the early years of primary school but also impact their students' achievement. It is interesting to note that in the results from Beilock et al. (2010), students were more likely to emulate the behaviour and dispositions of the same-gender teacher. This study was based in the U.S., where more than 90% of early elementary school teachers are female (Beilock et al., 2010). Statistics reported by the CESE showed that in Australia in 2020, 72.4% of primary school teachers were female (Centre for Education Statistics and Evaluation, 2020). The percentage of female teachers has also been steadily increasing over the past decade as male educators are increasingly less likely to enter the profession (Centre for Education Statistics and Evaluation, 2020). As previously discussed by Beilock et al. (2010), research shows that females are more likely to experience mathematics anxiety. Therefore, a higher instance of female teachers mean that students have a higher chance of being taught by mathematics anxious teachers.

Boaler (2002) discussed that one of the determinants of mathematical anxiety and avoidance is that girls, more so than boys, prefer a depth of understanding that is not the status quo in most mathematics classrooms. She believed there is a greater tendency for girls to want to understand deeply and make broader connections. However, the procedural nature of mathematics teaching could limit the depth and connection that could be achieved. In addition, Boaler (2002) claimed that due to stereotypical beliefs and the perception that girls inherently find mathematics more challenging, educators assume the deficiency lies with the female students rather than the classroom environment. Boaler (2015) also conducted a meta-analysis of 123 STEM programs for girls. She compiled the features that girls rated most highly as encouraging engagement and positive self-concept formation. The top four features were: hands-on experiences, project-based curriculum, real-life applications, and opportunities to work together. Mathematical learning is not only about content knowledge. Wenger (1999) discussed learning as a process of identity development, as students decide who they are and their capacity and capabilities. For many girls (and boys), the identities they perceive in mathematics classrooms are not compatible with the learning identity that has been developed prior. This disparity can lead to the development of mathematics anxiety, lack of engagement and participation (Boaler, 2015).

Teachers' views have been noted in the literature and form part of the message that students use to construct their mathematical identity. Exploring the views of students helps to further establish the classroom environment. A study by Bian et al. (2017), showed that girls as young as six years old have formed an idea that males are more naturally 'brilliant' than females. In this study, 400 children in the U.S. aged 5 to 7 years old, were asked to decide on the gender of a protagonist in a story. This protagonist was described as "really, really smart". At age 5, boys and girls were equally likely to associate brilliance with their own gender. By age 6, girls were significantly less likely to consider their own gender to be brilliant. Both boys and girls were more likely to identify the "really, really smart" character as a male. Somewhat counter-intuitively, when asked to choose which gender gets the better grades in school, girls mostly selected the female character. Girls appeared to believe that brilliance is an innate male characteristic but that girls can work hard to get good results. The authors also explored the idea of participation when an activity is described as being for 'really smart' students. They presented 160 children with two board games and told them one of the games was for children who were 'really smart', and the other was for children who 'try really hard'. The board game for students who 'try really hard' was selected equally by boys and girls. However, when the game for 'really smart' kids was presented, girls displayed less interest and motivation than the boys. This study demonstrated that boys and girls can view aptitude and cleverness as innate and gender-based. When the girls in the study rejected the board game for ‘really smart’ children, it showed that they did not consider themselves to be really smart, therefore it was not a game for them. It would have been interesting if the study had also explored the students’ attitude to developing intelligence as it appears that they considered being ‘smart’ as a rigid construct that they could not impact with perseverance or practice.

Girls often have a lesser self-concept in mathematics (Kyriacou & Goulding, 2006) and are more likely to experience negative gender stereotypes by the general public who view mathematics as a male domain (Leder & Forgasz, 2010; Vale, 2002). These views of mathematics as male dominated have also been seen as prevalent amongst students (Kaiser et al., 2012). In a study by Kaiser et al. (2012), it was noted that as students got older, stereotypes became more ingrained. The reasons given by both male and female participants in the study for perceived ability were that boys were more likely to be interested in mathematics, be logical and, later, develop their ability into a career. For girls to succeed in mathematics, both boys and girls believed girls would need to be diligent and persevere (Kaiser et al., 2012). Cvencek et al. (2011) found that these stereotypes developed as early as Year 2. Cvencek et al. (2011) conducted a survey asking Year 2 students in America (n=247) to consider how strongly they linked their own gender to mathematics. They found that students demonstrated what the authors refer to as an 'American cultural stereotype' of both boys and girls associating mathematics more with boys. It appeared, there was a common stereotype that assumed girls had a lesser native ability and therefore needed to work harder to do well in mathematics. Even countries that are considered progressive in terms of gender equity have shown stereotypical thinking to do with mathematics. Frid et al. (2020) conducted a survey with 241 Year 9 students in Sweden, which demonstrated that the boys in the study considered males to be better at mathematics whereas the girls were mostly neutral. An interesting finding in the Frid et al. (2020) study was that the student participants were asked to consider what mothers and fathers might say in response to the question: 'Who is better in maths?' The mean response for both boys and girls considered that fathers would choose boys and mothers would choose girls. The researchers did not interview the parents to see if there was any truth to the students' perception, which could have been revealing. This present study intends to explore parents' responses more fully.

Personal beliefs about competence are powerful factors that could account for gender differences in engagement. Denissen et al. (2007) studied the impact of interest, beliefs about competence and achievement in mathematics. These three factors were observed between Year 1 and Year 12. The study found that there was a correlation between the three factors. This meant that achievement was reliant on a similar level of interest and belief in competency. Stereotyping was damaging girls' self-concept and their beliefs in their competency. It was deemed conceivable that the development of a lesser self-concept in mathematics in a childs' formative years could contribute to a life-long pattern of avoidance and anxiety. Ramirez et al. (2012) showed that negative attitudes to mathematics occur in girls as young as first and second grade. However, they believed that there was very little understanding or research about the sources of children's mathematics stereotypes in preschool or the early years of formal schooling. Gunderson et al. (2012) posited that children at this age are especially likely to internalise mathematics-gender stereotypes as they are "at the peak stage of gender rigidity" (p. 154). It is highly likely that if girls are led to believe they are naturally incapable or less capable, they will turn their attention to subjects they believe they can experience success in and disengage with mathematics.

2.5.3 Mathematical Identity, Curriculum Documents and Pedagogical Practices

Curriculum may simply be considered by the layperson as that which is taught in classrooms. However, the selection of what is taught, it can be argued, is determined by its perceived value to students and society more broadly. Scott (2001) contended that the curriculum is influenced by the theoretical and ideological leanings of the scholars in the field while Lawton (2012) defined curriculum as "essentially a selection from the culture of society… certain aspects of our way of life, certain kinds of knowledge, certain attitudes and values are regarded as so important that their transmission to the next generation is not left to chance." (Lawton, 2012, p.6).

Considering Lawton's perspective regarding the idea that curriculum is a "selection from the culture of society" (2012, p.6), then it is also evident that there are aspects that are not selected and that which is considered important is determined by people with the power and voice to do so. Critical theory involves itself with understanding who has influence and who does not (Cohen et al., 2013). The 'curriculum wars' that have subsumed the drafting of curriculum documents in Australia are testament to the idea that there is value in what is included (and omitted), and also that it is those in power who are able to determine this (Zhou, 2021a). Historically, feminist critiques of this 'selection from the culture' have argued that this only perpetuates traditional and gendered perspectives and leaves the values and experiences of women and those from lower socio-economic backgrounds or minority groups as 'unselected' (Weiner, 1994). Elwood (2016) considered that curriculum documents are therefore socially constructed and that "curriculum reflects or promotes gender-appropriate behaviour and perceptions about boys and girls and how/ what they should learn" (Elwood, 2016, p.250). These constructs can then be applied to how achievement is defined, the way concepts should be taught as well as how they are assessed (Elwood, 2016).

2.5.4 Mathematics in the Media

In 1980, Benbow and Stanley published a paper that concluded that there was a large gender difference in the mathematical reasoning ability of gifted seventh-grade students. This resulted in media reports with headlines such as *Do Males Have a Math Gene?* (Newsweek, 1980) and *The Gender Factor in Math: A New Study Says Males May be Naturally Abler than Females* (Time, 1980) (cited in Jacobs & Eccles, 1985). The provocative headlines did not accurately construe the findings of Benbow and Stanley (1980) who had found that out of a study testing 9927 mathematically gifted students, the male participants outperformed the females in mathematical ability. Benbow and Stanley (1980) offered some explanations for this gap related to environmental factors which were omitted from the media articles, which had instead focused on biological or inherited factors. The Family Weekly wrote an article in 1981 based on Benbow and Stanley's findings titled *Sex + Math = ?* and reported that the study found that boys were born with greater mathematical ability (Jacobs & Eccles, 1985). Benbow and Stanley (1980) had made no such claims in their publication. The media reports did not provide the context of the study itself, that is, that the findings were based on gifted students only. Instead, they exaggerated the findings and applied them to the general population as innate characteristics (Jacobs & Eccles, 1985). In the original study by Benbow and Stanley (1980) they had considered broader factors that would impact on the results. These were that the students in the study were found through a talent search in which they needed to nominate themselves. This resulted in an unequal representation of genders with more boys (57%) than girls (43%). Benbow and Stanley (1980) also discussed the likelihood of societal conditioning and expectation that would be more likely to encourage boys to pursue and persevere with mathematics, more so than girls. These considerations were not mentioned in any of the media reports. The selectivity of the information the journalists presented was problematic. That they invoked the researcher's authority and endorsed a conclusion that was disingenuous and distorted was irresponsible. The result can be seen in a following study by Jacobs and Eccles in 1985 that measured the impact of these media articles on parents to see if it affected their perception of their own children's ability. Jacobs and Eccles (1985) compared responses from parents who had read media reports of the Benbow and Stanley article to those who had not. Jacobs and Eccles (1985) found that mothers who read the media reports were more likely than mothers not exposed to the media reports to think that their daughters had less mathematical ability, were less likely to succeed in in mathematics in later life, found mathematics more difficult, and had to work harder to succeed in mathematics. Interestingly, the same impact was not seen on the fathers who tended to become more egalitarian in their views on boys' and girls' ability after reading the media reports. Nevertheless, the findings of Jacobs and Eccles (1985) demonstrated that the media has played a role in exaggerating researchers' findings to support a gendered narrative. This in turn has had an impact on the readers of the media reports and in some cases, exacerbated existing gendered beliefs.

It is easy to dismiss stereotypes as a patriarchal hangover that has been (mostly) relegated to the past. However, this review has shown that both parents and teachers continue to hold these views, and it is not hard to find examples of the stereotypical narrative being further expounded by people who would be considered experts in the field. For example, in 2005, the President of Harvard University, Lawrence Summers explained why men were more heavily represented in the STEM fields "…in the special case of science and engineering, there are issues of intrinsic aptitude, and particularly of the variability of aptitude, and that those considerations are reinforced by what are in fact lesser factors involving socialisation and continuing discrimination" (Dillon, 2005, para 3). In 2017, a similar sentiment was expressed by James Damore, an engineer at Google whose thoughts on women's capabilities in STEM fields are now infamous. Damore stated that "there are natural biological differences between men and women which lead to differences in behaviour and personality, which in turn result in differences at a ‘population level’.” He went on to say "I'm simply stating that the distribution of preferences and abilities of men and women differ in part due to biological causes and that these differences may explain why we don't see equal representation of women in tech and leadership" (Devlin & Hern, 2017, para 2). More recently and locally, the Executive Dean of Science and Engineering at Macquarie University, Australia, apologised for making 'ill-judged' comments regarding the biological differences between men and women at an International Women's Day event (Zhou, 2021b).

In all these cases, the under-representation of women in STEM fields was acknowledged and its causes being considered. It is also true that in all these cases, the perceived cause of this under-representation was inadvertently addressed. Not by pondering perceived biological differences but by verbalising the stereotype that still exists about men and women having fundamentally different brains, and therefore different aptitudes.

2.5.5 Mathematical Role Models

Professor of Mathematics at Sydney University, Nalini Joshi (cited in Borrello, 2016, para. 3) lamented on the scarcity of women involved in the mathematical sciences in Australia. In 2016, women made up 30% of Associate Lecturers in mathematics in Australia. As the role becomes more senior, the percentage of women decreased. Women made up 20% of mathematics Associate Professors and only 9% at the most senior role of Professor (Borrello, 2016, para. 4). Joshi's own experience is evidence of this paucity of women in the mathematical field. She is the first female mathematician ever to be appointed at Sydney University and only the third female mathematician to be elected to the Australian Academy of Science. Joshi's example is evident in a broader context. Women are consistently under-represented in STEM fields of study and employment. OECD figures showed, on average, among OECD countries, women completed only 30% of STEM degrees (Spearman & Watt, 2013).

The mathematics department at the University of Melbourne recently made a significant statement about the value they place on female role models by advertising three positions for mathematics and statistical lecturers/ professors for females only. "We are very well aware and have been for some time that the number of women in our workforce within the school and within the sector of mathematical sciences is unacceptably low," Professor Owczarek told journalists (Jacks, 2016, para.5). Although, there is merit to the idea of encouraging women to these roles, the research by Stoet et al. (2016) suggests that there is not a strong case to be made that same-sex role models would make a substantive difference to the under-representation of women in the mathematical field. Stoet et al. (2016) hypothesised that countries with high representations of mothers working in STEM jobs would have a positive effect on disposition towards mathematics for girls. However, this was not the case as they found there was no reduction in mathematics anxiety in female students. In addition, they found no correlation between the profession a mother holds and a more positive regard for mathematics by females. This seems contrary to the beliefs of many socio-cultural researchers who would expect gender-related differences to stem from what is being modelled by significant adults (Bagès, Verniers, & Martinot, 2016).

2.5.6 The Intersection of Mathematical and Cultural Identity

Historically, gendered attitudes and stereotypes have been documented and monitored using one of the most widely used instruments for this task, the *Mathematics as a Male Domain Subscale* of the *Fennema-Sherman Mathematics Attitude Scales* (Fennema & Sherman, 1976). In 2000, Leder and Forgasz updated this instrument to allow for greater validity and to allow respondents to select an item as a female domain instead of the previous instrument, which only offered ‘male’ or ‘neutral’ options (Leder & Forgasz, 2000). The *Who and Mathematics* instrument provides a snapshot of participants' perceptions of ability and aptitude and asks the participant to nominate which gender is more capable in certain aspects of mathematics (Leder & Forgasz, 2000). Because the *Who and Mathematics* instrument has been utilised in many different cultural contexts, it has provided a good indicator of the role culture plays in developing mathematical identities.

There have been a number of international studies conducted using the *Who and Mathematics* instrument. Three of these have been selected; an Australian study in 2000, to further understand the way Australian children have related to mathematics; a Greek study to contrast a more patriarchal society; and an Arab-Israeli study to understand the way in which two quite distinct cultures, living and working alongside one another might impact on gendered views.

In Australia, 861 high school students in Victoria took part in a study conducted by Leder and Forgasz in 2000, using the *Who and Mathematics* instrument. The mean results showed that the students mostly viewed mathematics as a non-gendered subject area. However, there were 18 statements that showed statistically significant views from the students. The student participants thought that boys were more likely to be *asked more questions by the maths teacher*, *give up when they find a maths problem too difficult, have to work hard to do well, need maths to maximise employment opportunities*, *get wrong answers in maths*, *need more help in maths, not be good at maths, consider maths boring, find maths difficult* and *tease girls if they are good at maths*. Students thought that girls were more likely to *think it is important to understand the work*, *care about doing well*, *think they did not work hard enough if they didn't do well*, their *parents would be disappointed if they didn't do well*, *think maths will be important in their adult life*, *worry if they don't do well in maths* and *think maths is interesting*.

The picture painted by the students' responses showed that they viewed mathematics as more of a female domain and that boys were having some difficulty with both mathematical aptitude and effort (Leder & Forgasz, 2000). However, it was different from what Leder and Forgasz (2000) had hypothesised based on previous, similar studies (Table 2.2). It is regrettable they did not list these studies so that further comparisons could be made. However, they note that the expected view that mathematics would be considered a male domain had shifted much more so than they had expected. They considered that this reflected a more progressive view that girls were even more capable than the boys, and that this was a rejection of outdated stereotypes (Leder & Forgasz, 2000).

Table 2.2

Leder and Forgasz' (2000) findings compared to previous research

Who and Mathematics Statement	Hypothesis based on research prior to 2000	Leder and Forgasz' findings (2000)
Maths is their favourite subject	M	F
Think it is important to understand the work	F	F
Are asked more questions by the maths teacher	M	M
Give up when they find a maths problem too difficult	F	M
Have to work hard to do well	F	M
Enjoy mathematics	M	F

Care about doing well	M/F	F
Think they did not work hard enough if they don't do well	M	F
Parents would be disappointed if they don't do well	M	F
Need maths to maximise employment opportunities	M	M
Like challenging maths problems	M	ND
Are encouraged to do well by the maths teacher	M	ND
Maths teacher thinks they will do well	M	F
Think maths will be important in their adult life	M	F
Expect to do well in maths	M	F
Distract others from maths work	M	M
Get wrong answers in maths	F	M
Find maths easy	M	F
Parents think it is important for them to study maths	M	ND
Need more help in maths	F	M
Tease boys if they are good at maths	M	M
Worry if they don't do well in maths	M/F	F
Are not good at maths	F	M
Like using computers to solve maths problems	M	M
Teachers spend more time with them	M	ND
Consider maths boring	F	M
Find maths difficult	F	M
Get on with their work in class	F	F
Think maths is interesting	M	F
Tease girls if they are good at maths	M	M

Note. M= Male, F= Female and ND = no difference

It was encouraging to see a more positive view of girls' ability and these data challenged historical stereotypes (Leder & Forgasz, 2000). The authors of the study speculated that this demonstrated a shift in thinking and that this indicated that boys might now be considered the disadvantaged group (Leder & Forgasz, 2000). This new thinking was reflected in the title of the article *'Mathematics and Gender: Beliefs: They are a changin'*. Qualitative data would have been helpful to understand student responses further, and especially interesting considering that this is a different perspective to the male dominated mathematics domain discussed in the literature review thus far (Thomson et al., 2013; Vale, 2008)

In 2002, Barkatsas, Forgasz, and Leder used the *Who and Mathematics* instrument in Greek high schools and found a huge contrast to the Australian study conducted by Leder and Forgasz in 2000, which had shown a positive regard for girls' abilities and effort and indicated that boys may be the disadvantaged group when it came to mathematics learning. The results in the Barkatsas et al. (2002) study showed stereotypically gendered ideas that mathematics was a male domain, especially for statements related to ability and interest in mathematics, parental beliefs, and teacher expectations. The reason for this contrast was explained by Barkatsas et al. (2002) to be due to the more conservative and patriarchal Greek curriculum and culture, combined with a lack of systemic intervention to increase female participation. The authors believed this was reflected in more traditionally stereotypical responses. The more optimistic outlook is that intervention and attention to gendered stereotypes have impacted Australian students. This indicates that students are sensitive to gender cues and norms, and as a result, their views appear to have shifted.

The *Who and Mathematics* instrument was also used to study Israeli students by Forgasz and Mittelberg (2008). Their aim was a cultural contrast between Year 9 Israeli-Jewish (n=103), Israeli-Arab (n= 107) and Australian (n=250) students regarding gendered beliefs. The results showed that the Israeli Jews rejected that mathematics was either a male or female domain as most of their responses were *no difference*. Their views were similar to Leder and Forgasz's (2000) study of Australian students. This study also reported that Arab females outperformed males in mathematics and that girls were perceived to be better mathematics students. This is consistent with findings in the students' TIMSS results (Forgasz & Mittelberg, 2008). However, when student participants responded to post-school and workforce-related questions, Arab students viewed mathematics as more useful for males than females. This reflects the cultural reality that Arab women in Israel are less likely to participate in the workforce than their Israeli counterparts (Ayalon, 2002). It is interesting to note that the limited workplace opportunities for Arab-Israeli women do not impede their success in the classroom.

2.5.7 Mathematical Expectations in Later Life

Eccles (2011) considered the motivating factors that impact participation and engagement in mathematics and developed the Eccles Expectancy Value Model of Achievement-Related Task Choices to understand the external processes influencing mathematical identity. Within this model, Eccles (2011) linked educational, vocational and other achievement-related choices to do with mathematics. Importantly, Eccles connected mathematical identity to a variety of factors considered 'interpretive systems'. These systems included 'inputs of socialisers' such as parents, peers and teachers, as well as gender-role and cultural beliefs, self-perceptions and perceptions of tasks and choices (Eccles, 2011). Eccles' (2011) research showed that individuals continually made choices, both consciously and subconsciously regarding how they spend their time and energy. This impacted on subject selection and vocation and were heavily influenced by processes of socialisation and cultural norms (Eccles, 2011). Eccles asserts that the source of the decision making related to four factors:

1) The utility value of the task to achieving personal short and long-term goals or external rewards

2) Intrinsic interest and enjoyment in a task

3) Attainment value – the value an activity has in relation to one's social or personal identity or core values

4) The cost of engaging in the activity.

When this framework is used to predict vocation, Eccles showed that gender can be seen as a predictor of the likelihood of males or females to choose certain careers (Eccles, 2011). For example, Eccles' earlier 2007 research on 1000 students in American high schools showed that students of both genders believed that working as a health professional required high levels of efficacy for working with people. In addition, individuals placed different levels of value on the skill of working with people and this was viewed as a very good predictor for their likelihood of working in the health profession. Therefore, the students who placed a high personal value on the skill required to work well with people, were also more likely to choose to work as a health professional. The male participants were much more likely than the females to say that they did not aspire to develop efficacy for working with people and instead say they valued occupational prestige, this in turn predicted their likelihood to choose their vocation in a business or law related profession rather than a health profession. This also predicted the subjects they were likely to choose in senior secondary school, as they were responding to prompts from universities for university entry.

In addition to selecting vocations that resonated with students' personal values and identity, Eccles (2011) claimed that peers, teachers and parents play a role in reinforcing gendered roles and vocations. She suggested that peers who reinforce gendered roles tend to engage in different activities, develop different competencies, patterns of expectations and success and go on to acquire different values and goals. Parents can reinforce this by endorsing traditional gender-role stereotypes. Jacobs and Eccles (1992) showed that parents in their study tended to underestimate their daughter's capabilities in male-type activities like sport and physics yet overestimate their son's capabilities.

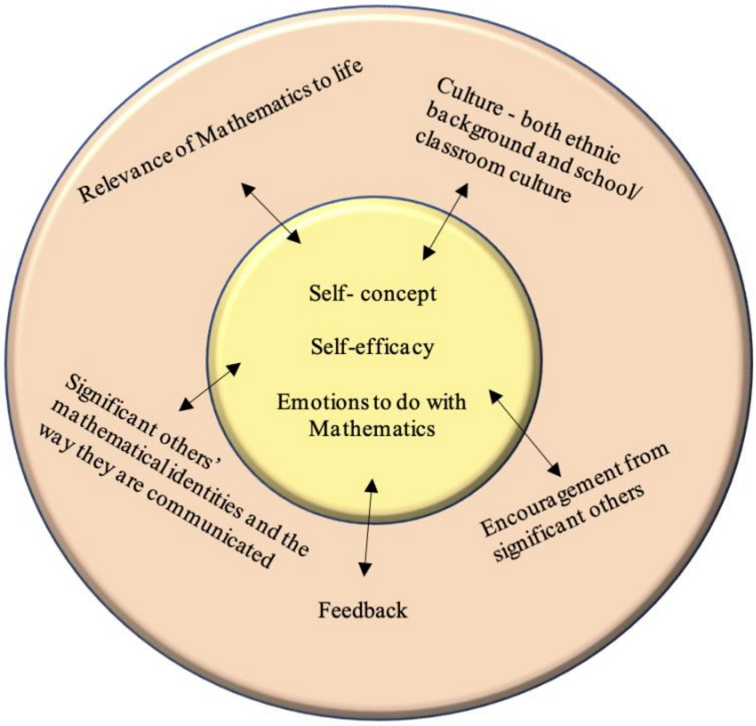
Eccles' (2011) research has added a nuanced and valuable contribution to the field by acknowledging that males and females select different values and occupational pathways, and that rather than this being a consequence of innate characteristics, it is a complex response to social and cultural cues that assert particular roles to each gender. The end result is that the social cues and external influences surrounding boys and girls in their formative years impact their vocational pathway and mould their perception of the values of particular skills, as well as their own skill level and beliefs about where they will find success.

2.5.8 Adding to the Conceptual Framework

The second layer that has been added represents the people and influences closest to the student learner (Figure 2.4). The inner-circle shows the internal process as children make sense of the information they receive around them. These influences are flexible and children's mathematical identity is dependent on their personal context. However, this can be considered a visualisation of the influences on mathematical identity. An example of how this works could be seen if a child is evaluating their aptitude and self-efficacy as they face mathematics work they find challenging. If they are concomitantly observing that the adults around them that are 'good' at mathematics are men, while mathematics anxiety is being conveyed by women, then these significant mathematical identities and the way they are communicated can influence the formation of the inner layer. As the child grows and develops their mathematical identity, they in turn will become 'significant others' and communicate their mathematical identity to learners, whether it is confident or frail.

Figure 2.4

Conceptual Framework: The second layer of students' mathematical identity



2.6 Who Becomes a 'Maths Person'?

Who is selecting mathematics for further study in the later years of secondary school and university? Who expects that mathematics will play a role in their adult life and career? Studies by Watt in 2005 attempted to identify the factors that lead to more boys than girls taking higher-level mathematics subjects and intending to forge careers requiring mathematics. Watt (2005) interviewed 60 Year 9 students in Sydney to understand why they would or would not pursue mathematics-related careers. She found that boys were twice as likely as girls to nominate future careers that involved mathematics and the main reason to choose mathematics subjects in senior years was due to the perception that this would enhance employment opportunities. The second-highest nominated response was to do with the perception of capability in mathematics. That is, students who thought they were successful in mathematics were more likely to continue to study mathematics subjects in senior years (whether their perceptions were accurate or not). Watt (2005) found that prior success did influence subject choice but not as significantly as students who rated the intrinsic value of mathematics as high.

Watt continued to explore the issue of motivation in relation to subject selection and employment in 2006 with a longitudinal study of 459 students from Years 9 – 11 in New South Wales, Australia. She again found that boys were more likely than girls to plan to enrol in mathematics in the senior years of high school. The boys' projected career intentions show that they were more strongly considering mathematics-related careers than girls. Boys rated mathematics as more valuable for later study and employability which was seen to be a much stronger motivator to select mathematics subjects than prior performance. Interestingly, Watt (2006) noted that where girls rated the utility value of mathematics more highly, they were more likely to aspire to careers requiring mathematics and subsequently were more likely to select mathematics courses. However, girls needed to rate mathematics as 'highly' useful to lead to their choice of mathematics career, compared to boys rating mathematics as 'moderately – highly' useful to see similar subject choice selection. This indicates that the utility of mathematics must be considered clearly worthwhile by girls more so than boys to motivate their subject selection.

An analysis by Thomson et al. (2013) showed a similar conclusion regarding the importance of the perception of the utility of mathematics. Their analysis of 2012 PISA data regarding students' attitudes towards mathematics found that while one-fifth of boys did not believe mathematics was relevant for future study, as much as one-third of girls considered mathematics irrelevant to their future study. In each of the four sub-categories used to measure the instrumental motivation for mathematics, girls' responses showed that they had a lesser belief than boys that mathematics was: worth the effort to increase employability; worthwhile to increase career prospects; an important subject in relation to later study; or is valuable as a skill-building subject to assist the process of getting a job (Thomson et al., 2013).

The culmination of senior years of study in secondary school is measured by the Higher School Certificate (HSC) in NSW, Australia. Mathematics is not mandatory in the two final years of secondary school. Table 2.3 shows the Year 12 participation in mathematics subjects (NESA, 2021) The table is organised from the lowest to the highest level of senior secondary mathematics, although Mathematics Standard 1 does not contribute towards the HSC. Reviewing the mathematics courses that do contribute to the HSC shows that as the difficulty increases, girls' participation decreases. Mathematics Standard 2 shows an equal gender balance, seeing as girls make up 51.7% of the cohort. However, in the 2021 HSC Extension 2 Mathematics course which is the most challenging, girls represented only 35% of the cohort.

Table 2.3

Participation in Mathematics in the HSC in 2021, by Gender

	Males	Females	Females as % of the cohort
Mathematics Standard 1	3223	2245	41%
Mathematics Standard 2	14801	16080	52%
Mathematics Advanced	9049	8004	47%
Mathematics Extension 1	5219	3535	40%
Mathematics Extension 2	2107	1125	35%

Note. Girls' candidature in the 2021 HSC was 51.7% of the cohort

Watt et al. (2006) tracked students in Australia and the U.S. in Years 9 - 11 and 8 - 12, respectively, to understand why young women were not choosing mathematics as part of their subject selection. They found that in Australia, there was a lower rate of selection of mathematics by girls and that this was not linked to actual ability. Instead, interest and enjoyment in mathematics were the main predictors of mathematics subject choice with perceived ability also playing a role. Interestingly, boys' perception of their mathematical ability was significantly higher than the girls in both the Australian and U.S. setting. The researchers suggested the first 'leak' in the pipeline in Australia is the transition point from Year 10 to Year 11 as girls were less likely to select mathematics, and when they did, they were less likely to select high-level mathematics. The U.S. context showed different results as there was no difference in mathematical subject selection between the genders. The authors determined that the differences between the Australian University and U.S. college admission process had a meaningful impact as U.S. college admissions place greater emphasis on mathematics coursework. This indicates that when girls do not see the utility of mathematics to their university and career pathway, they retreat from STEM subjects and careers.

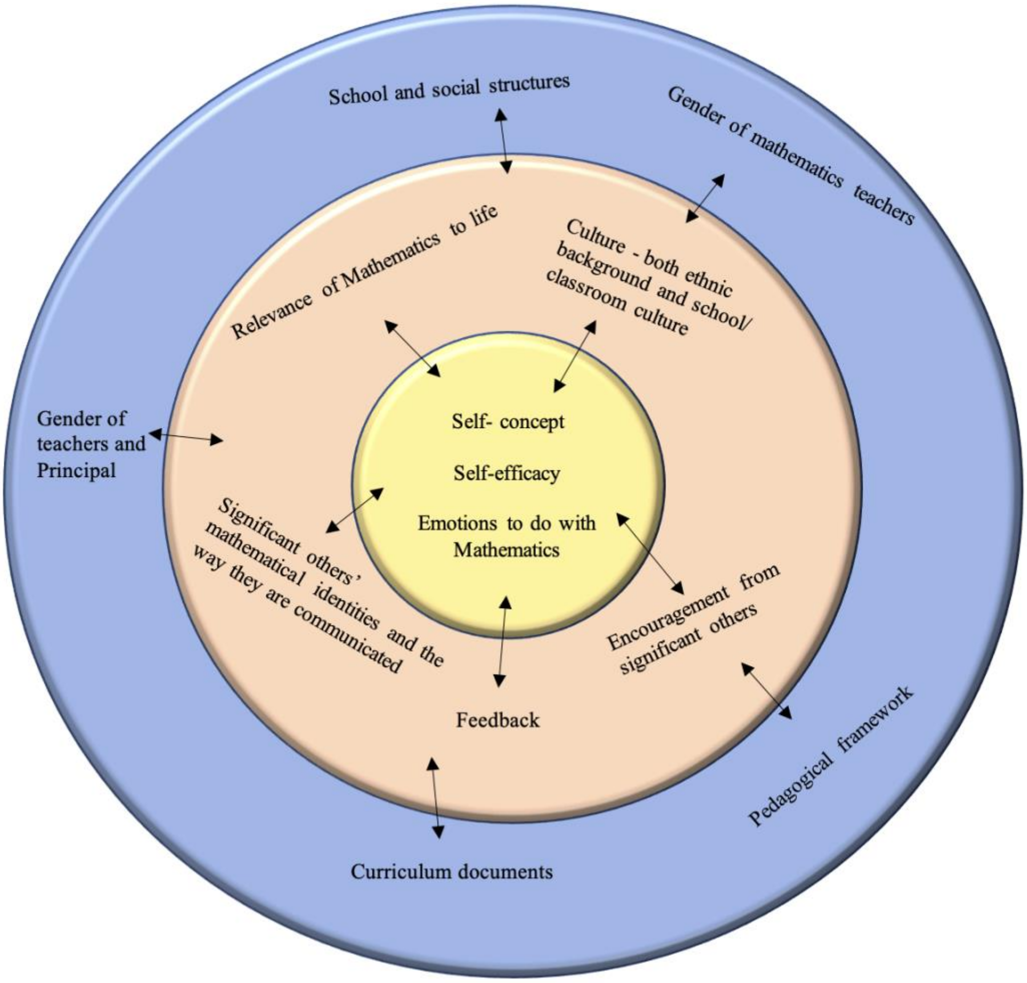
Mathematics has been called the 'critical filter' for students, allowing movement into high-profile and high-status positions (Sells, 1980). The pipeline metaphor has been critiqued for labelling young women as passive actors in a system with no control (Herzig, 2004). A more apt metaphor might be a freeway, where girls and women are the drivers, choosing their preferred route. It is a proactive choice rather than a reactive incident. However, there are broader implications as girls and women choose to move away from STEM subjects and careers. Based on the research discussed, it is clear girls are not rejecting mathematics because of a lesser ability than boys. Instead, they view mathematics as less relevant or worthwhile to pursue. When the themes discussed are placed into a conceptual framework of factors influencing mathematical identity, the messages that girls receive about their mathematical identity can be more readily seen. These messages frequently inform girls that they are inherently less capable, must work harder to keep up with the boys, lack the requisite characteristics of a 'maths person' and that mathematics has less utility for them in later life.

2.7 Adding to the Conceptual Framework

The final layer of the conceptual framework involves influences that are irregular or indirect (Figure 2.5). However, even though this outer layer does not play a direct role on the development of a child’s mathematical identity, the literature has shown that it is relevant. Curriculum and pedagogical changes can impact the perceived relevance of mathematics with the implication that the learner clearly sees the utility of mathematics to themselves and future study or work.

Figure 2.5

Conceptual Framework: The external influences on students' mathematical identity



2.8 Summary of Literature

There has been an increased focus on girls' mathematical achievement and participation since the 1970s. Since then, a concerted effort by researchers and educators to redress issues of equity and access for girls has been undertaken. Most researchers believe that gender is not a reliable predictor of achievement. This provides a paradox: although girls' and boys' achievements in mathematics are similar, girls are still displaying attitudes and self-concept about mathematics that are demonstrably more negative than boys. Gender stereotypes propagated by parents, teachers and the wider community influence these perceptions in children as early as six years old, causing girls to avoid mathematics in high-school, university and career choices.

There are a combination of interrelated factors that have been discussed. Importantly, gendered ability has no significant impact on students' achievement. The cultural studies that have been reviewed in Australia, Israel and Greece show that culture plays a significant role in determining dispositions and students' self-concept about mathematics. The role of parents and teachers in endorsing gender stereotypes has been shown to be important in contributing to affect and achievement. In addition to sending messages to children that girls and boys have different capabilities as mathematicians, parents and teachers also downplay the value of mathematics as being relevant in later life for girls. For girls, this means being told by significant adults that first, they may not have the capacity to achieve in mathematics, and second, it is not that important anyway. If girls are internalising these messages, then it is only natural that they would avoid mathematics.

A great deal of research has been conducted on children from Year 2 onward, but none have explored the mathematical attitudes children bring with them to school and how teachers influence these views in the first year of formal education. Therefore, there is a need to research the views that parents impart on children before they begin school and the views that early years' teachers impart on children in their first year of school. There is value in understanding exactly how early negative self-concept begins and what causes this in the early years of school. If teachers and parents can understand where and when negative self-concept creeps in, interventions can be made. This is important to interrupt the uptake of negative and stereotypically gendered views towards mathematics. Furthermore, this will create an inclusive and welcoming environment for all mathematical learners throughout their school experience, enabling students to forge a mathematical identity free of unhealthy stereotypical beliefs and expectations.

2.9 Theoretical Framework

Critical theory distinguishes itself from other theories as it seeks to understand an existing situation and transform the situation into one that encourages inclusion and agency for all participants. Habermas (1972) defined critical theory as having an 'emancipatory interest'. This is in contrast to the characteristics of positivist and interpretivist paradigms which he considered had scientific or practical interests. An emancipatory interest is anathema to the status quo and challenges the power structures that perpetuate the current situation. Morrison (1995) built on this idea when he claimed that critical theory should have an ideological function and that the research constructed using a critical theory lens is not neutral. Kincheloe

(2012) said that this emancipatory intention is concerned with praxis, action that is "informed by reflection with the aim to emancipate" (p. 177). The assumption is that the existing power structures prevent individual and social freedoms and need to be exposed to attain the ideal state of social justice. In addition, critical theory most closely aligns to the axiological concerns of a transformative paradigm. The transformative paradigm emphasises that research should be for the greater social good (Mertens, 2007).

The concepts of *identity*, *girls* and *boys, children* and *relationships* in the context of mathematics education challenge the status quo, which despite generations of awareness is still gendered. The aim of the study is to explore the way these are connected and informed by social structures and the people within a school community. Identity, and in particular the construct of gender, is a clear theme within this research, which necessitated a framework that could accommodate theories related to gender.

Other theories, such as gender theory, social learning theory and cognitive development theory were considered, but dismissed, Gender theory can be separated into three main areas: biological, social and cognitive (Miller, 2016). The biological approach relates to genetic and hormonal or neurological differences between males and females that have an evolutionary basis. For example, if boys demonstrate greater success in mathematics tasks relating to spatial awareness than girls, a gender researcher with a biological approach might hypothesise that this is to do with the evolutionary requirement for males to have once been skilled hunters (Miller, 2016). However, as discussed earlier in this chapter, there are no statistically significant differences in ability in mathematics between boys and girls (Lindberg et al., 2010; OECD, 2009; Vale, 2008) and so this approach is not applicable to the current study.

The social approach views the social interactions that support or discourage certain behaviours and are closely associated with *Social Learning Theory*, developed by Bandura in the 1960s (Miller, 2016). Social Learning Theory acknowledges the key role that modelling plays in constructing gendered cues and identity in children. During the 1980s, Bandura revised Social Learning Theory to acknowledge cognitive processes and choice as he considered children as active participants in forming their identity. This became known as *Social Cognitive Theory* which was applied to gender development research in 1999 by Bandura (Miller, 2016).

The cognitive approach to gender can be traced back to Kohlberg in 1966 with the development of *Cognitive-Developmental Theory* (Miller, 2016). The influence of Piaget can be seen as Kohlberg asserted that children’s understanding of gender was related to their age-related changes in cognitive development (Miller, 2016). He claimed that as children grew older, they became more motivated to align their behaviour to expected gender norms. Kohlberg's ideas spurred the approach of *Gender Schema Theory* which emphasised the way that gendered messages are shared in our society and that children's self-concept and self-esteem will be assimilated in their gendered schemas (Bem, 1981)

Given the focus on social structures such as schools and families in this current study, both the social and cognitive approaches to understanding gender are relevant and are drawn on at times. However, these approaches do not attempt to explain inequity within the normalised social structures, they simply explain that children will be responsive to social cues. They do not look to remedy inequity which is the aim of the study.

This current study seeks to understand the inequalities surrounding Kindergarten students, specifically related to mathematical learner identity. This study interrogates the socially and cognitively constructed knowledge of what boys and girls perceive they can and cannot do, based on their understandings of gender, and in this sense is drawing on some of the theoretical underpinnings established by Bandura and Kohlberg. This study has aimed to view how boys and girls understand their gendered role specifically as mathematics learners, as they establish their understandings and beliefs about their learner identity and the way they perceive that this is influenced by their gender. In addition, analysis has attempted to find which stereotypes are supported and relayed to children. For example, parents or teachers might rationalise a bias towards one gender or another based on their own experiences 20 years earlier in school, or they may observe vocations as gendered in their community and then subconsciously endorse gendered opportunities to children. Tyson (2006) has observed that many of our viewpoints are formed based on a patriarchal understanding of social norms. She asserts that our own perspective is not objective since we are also products of this patriarchy. It is only in deconstructing viewpoints that we can move towards a more objective outlook (Tyson, 2006). Within this study, the aim is to deconstruct perspectives to see where gendered stereotypes have influenced children. Once these specific details are known, an appropriate intervention point can be identified, therefore encouraging more equitable educational environments and learner identities for young learners.

Critical theory provides the theoretical framework for this research to understand *what is* and contrast it with *what should be*. It is a way of seeing the world, and acknowledges that the researcher, participants and society as a whole interpret concepts and constructs as they themselves understand them (Tyson, 2006). This understanding will intersect with other constructs such as their gender, culture, religion, community, education and formative experiences. The result is that there are multiple interpretations. Critical theorists refer to these interpretations as ‘realities’, this is because they are real to the person who has interpreted it as such (Tyson, 2006) For example, a group of people may all read exactly the same book, critical theory tells us that some may focus on the relationship between the characters, some might think about the narrative and how it might reflect contemporary society, some might be concerned at the lack of representation of certain groups of people and wonder about how they might fit in to the narrative, or what their absence tells the reader about their voicelessness. The perspectives they have brought with them, influence their interpretation or their reality (Tyson, 2006). Within this study, the intention of critical theory is to provide an account of the case in question and analyse inequities and address them (Cohen et al., 2013). In particular, utilising the lens of critical theory should lead to an understanding of who the powerless and powerful are, whose voices are not being heard and whose voices are given privilege. In doing so, the sequence of events that leads to a group of people being disadvantaged should also be exposed. By deconstructing and interrogating the elements of a case, it can be determined where inequities may lie and consequently how structures can be reformed and bettered for all participants and the progression of society.

An example of this could be seen in the interrogation of the relationship between schools and society. Recently, in Australia, new curriculum documents have been implemented for years K-10. Critical theorists would be unsurprised at the number of different and interested parties who have been contesting what should and should not be represented in these documents. The previous Education Minister Alan Tudge showed his concern at the use of the word 'invasion' to describe the British colonisation of Australia (Zhou, 2021a). He said that the curriculum should reflect Australia's 'great successes', pointing out his concern about a portion of the Year 9 history syllabus asking students to consider 'different historical interpretations' of World War I. He is not the first politician to occupy themselves with curriculum reform. In the 1990s, Prime Minister John Howard claimed the syllabus promoted a "black armband view of Australian history" (Hurst, 2021, para. 26). In 2010, Prime Minister Julia Gillard announced the reformed syllabus documents and referred to Howard's comments by declaring these presented neither a “black armband nor white blindfold” view of historical events (Hurst, 2021, para. 27). In 2014, Tony Abbott's government then launched a curriculum review with the goal of removing "partisan bias" (Hurst, 2021, para. 28). The present 2021 iteration of the curriculum once again, has raised concerns regarding representation, identity and voice in documents that will be implemented in schools all over Australia. These politicians have understood that schools have the power to perpetuate or reduce inequality through the chosen curriculum and that this contributes towards a social construction of knowledge that is largely accepted across generations and can have the power to influence what is valued, social participation and expectations of societies. The ideological debates will continue over the content and semantics of the curriculum documents. The politicians who have the privilege and position to voice their opinions may not always be aware of the social groups without equivalent representation and voice in society, who are not prioritised or considered in the curriculum. Critical theory demands closer inspection to see whose voices are heard or omitted, to question and transform the power structure to become more democratic and representative (Cohen et al., 2013).

To review the various elements that are influencing children and informing their identity, a conceptual framework has been developed to further understand who or what is influencing children. This current study hypothesises that parents and teachers have a strong influence as role models that interact with children routinely. The social and cognitive theorists that have been reviewed have been relevant in informing the processes involved as children begin to form their identities. As the literature was reviewed, a visual representation of the social influences surrounding children was constructed. This study began by placing the child at the centre, and then analysing who or what has influenced children's social and cognitive construction of their mathematical identity, based on their gender. As the study progresses and responses are analysed, it becomes clearer which precise elements are having an influence on children in this case, as they are forming their mathematical identity. By deconstructing and reconstructing the elements involved in this way, it makes each influence much clearer and provides a snapshot of a case and where misunderstanding or bias might be occurring, in order to rectify it. If for example, it becomes clear that children are referring to the jobs their parents do as 'male' or 'female' and then feel their own future vocation is somewhat predetermined by their gender, and therefore their role at school is also gendered, this study can pinpoint an area of influence that is inequitable and develop solutions to address these concerns more appropriately. As the study has progressed, areas identified can be seen as contributing or limiting to a child's perspective of what they are capable of. Critical theory is importantly first "informed by reflection" (Kincheloe, 2012, p. 177) which this study sets out to do by understanding all of the various social interactions children have in their school community. Critical theory however has a dual purpose, with the aim of also redressing inequity (Kincheloe, 2012). And so, once there is a complete picture of the way that children are developing their mathematical identity, this study also considers where there is inequity or injustice, in order to develop interventions and school communities that provide access and equity for all of their students.

Chapter Three: Research Plan

3.1 Overview

This chapter describes the paradigm and the researcher's epistemological stance and acknowledges these philosophical foundations as a guiding force for conceptualising subsequent research decisions. This chapter also outlines the methodology and the selection of mixed methods single case study. The qualitative and quantitative methods used are also described. The ethical considerations required to construct the study are outlined, as are the principles established to enhance its trustworthiness.

Table 3.1

Overview of Chapter Three: Research Plan

3.1	Overview
3.2	Paradigm
3.3	Philosophical Decisions
3.4	Case Study
3.5	Methods of Data Collection
3.6	Methods of Data Analysis
3.7	Ethical Considerations
3.8	Summary

3.2 Paradigm

This study utilised the worldview of pragmatism, which is frequently associated with mixed methods research (Cresswell & Plano Clark, 2011). There is a focus on the multiple methods being used, in addition to the utility of these methods in responding to the research question and culminating in practical recommendations (Cresswell & Plano Clark, 2011).

Initially, the multiple phases of the data collection presented the opportunity to employ multiple worldviews. That is, the first phase and collection of quantitative data (surveys) presented an opportunity to select a postpositivist world view. The specific variables, empirical measures and positioning with a deductive a priori theory that could be tested, meant that this could be an ideal worldview for the first phase of the study. The first two subsidiary research questions demonstrate that these meet the criteria for a postpositivist view as defined by Cresswell and Plano Clark (2011, p.40):

- Determinism, or cause and effect thinking
- Reductionism, by narrowing and focusing on select variables to interrelate
- Empirical observation and measurement
- Theory verification

The first two subsidiary research questions are *What are parents' and teachers' views of girls' and boys' mathematical identities?* And *How are boys and girls describing their mathematical capabilities and relationship with mathematics at the beginning and end of their first year of school?*

It is evident that these questions could be answered, at least to a satisfactory point, using postpositivist research methods to uncover the participants' views using a quantifiable means. However, the intent of this study was to gain a complete understanding of parents', children's and teachers' views, requiring a more qualitative approach. Post-positivism is not a suitable choice when moving into the qualitative phase of the research. In this phase, the intent is to follow up on and explain the survey results, to look for multiple meanings from the participants, to gain a depth of understanding that is not possible in the earlier quantitative phase (Cresswell & Plano Clark, 2011). Instead, a constructivist paradigm allows for the depth of understanding, multiple participant meanings, social and historical construction and theory generation required to answer the subsidiary research question (Cresswell & Plano Clark, 2011):

What is the relationship between the views that parents, teachers and children hold regarding gender and identity? As well as the overarching research question:

How are girls' and boys' mathematical identities being informed as they begin school in Australia?

It is possible to work with dialectical perspectives although there are contradictory views to reconcile between post-positivism and constructivism (Greene & Caracelli, 1997). In addition, the intent of this research is to merge the data collected in the quantitative and qualitative phases for analysis and to see how these data interrelate with one another. This study employs pragmatism because it allows for a pluralistic perspective with the focus on collecting multiple data sources to best answer the research questions (Cresswell & Plano Clark, 2011).

Pragmatism is oriented towards a "what works" approach and provides the researcher with the means to best respond to the research questions using both objective and subjective knowledge. Tashakkori and Teddlie (2003) outlined the utility of pragmatism in mixed methods research because:

- Both quantitative and qualitative methods can be utilised.
- The research question is the primary concern – more so than either the method or the philosophical worldview that underpins the method.
- The limited binary choice of the dichotomy between post-positivism and constructivism should be abandoned.
- A practical and applied research philosophy should direct methodological choices.

Biddle and Schafft (2015) add further to this definition when they discussed the strong emphasis on axiology in pragmatism. That is, the social and ethical nature of pragmatism in its earliest iterations. Biddle and Schaft (2015) point to early pragmatist researchers such as Peirce, James, Meade and particularly Dewey who viewed research as a social endeavour and a means to contribute to the social good. More recently, Teddlie and Tashakkori (2009) have observed a shift away from this emphasis on values and claim that although "pragmatist researchers believe that values play a large role in conducting research and in drawing conclusion from their studies… they see no reason to be particularly concerned about it" (p.90). It was the intent in this current study to align more closely with the foundational pragmatist researchers and consider the context of community and the greater social good to inform the axiological position.

Values inherent in this study are those to do with gender and the associated social expectations and supports provided based on the participants' understandings of gender. The research questions sought to understand the participants' values about gender and mathematics and interpret those views. This study looked at the values held and shared between parents, teachers, and children to determine how children form their mathematical identity with the intent to increase equity and access. Given this perspective, it is evident that values play a large role in this study. To ensure that values were appropriately addressed within this pragmatic mixed methods research study, the transformative paradigm has also been incorporated. Mertens (2007) has argued that a transformative paradigm is essential to address "recognition of power differences and the ethical implications that derive from those differences in terms of discrimination, oppression, misrepresentation, and being made to feel and be invisible" (Mertens et al., 2010, p.195). Mertens et al. (2010) further proposed that mixed methods research should provide a basis for social change. She indicated that the researcher should be focused on issues of power and power relationships, rather than simply basing methodological choices on pragmatics because it is an inadequate way of addressing axiological concerns (Mertens et al., 2010). In her earlier work, Mertens (2003) asserted:

> The transformative- emancipatory paradigm places central importance on the lives and experiences of those who suffer oppression and discrimination, whatever the basis of that is – be it sex, race/ ethnicity, disability, sexual orientation, or socioeconomic status. Researchers working within this paradigm are consciously aware of power differentials in the research context, and they search for ways to ameliorate the effects of oppression and discrimination by linking their research activities to social action and wider questions of social inequality and social injustice. (p.159)

Morgan (2014) also endorses the idea that mixed methods researchers more recently have emphasised the practical aspects of pragmatism but have avoided much serious contact with the philosophical origins of pragmatism that were established as a means of promoting social justice. The transformative or emancipatory paradigm does not necessarily establish itself as an alternative to a pragmatic approach. Cresswell and Plano-Clark (2011) considered the transformative paradigm as complementary to pragmatism therefore, this current study utilises the transformative paradigm as an axiological complement to the existing pragmatic norms of practice.

Where once it was accepted that mathematics was a male domain and that male voices were privileged (Leder, 2019a), the transformative view explains this reality is flexible and responsive to influence (Cohen et al., 2013). Perceptions and values have been explored in this study by examining parents', teachers' and children's views, acknowledging that many lenses such as social, cultural or economic constructs have contributed to these perspectives. This study looks at the realities held and shared between parents, teachers, and children to determine how children have formed their mathematical identity. In doing so, inequities limiting students in mathematics have been explored, and interventions to address these will be recommended.

The decision to adopt the paradigm of pragmatism including axiological considerations from the transformative paradigm means that philosophical choices made relating to ontology, epistemology and axiology should be informed by the paradigm's focus on what works best in answering the research questions, alongside the transformative 'emancipatory interest' described by Mertens (2007). This can be framed as "action that is informed by reflection with the aim to emancipate" (Kincheloe, 2012, p.177). The ontology, epistemology, and axiology influence and inform the methodology (Lichtman, 2013).

3.3 Philosophical Decisions

3.3.1 Ontology

Ontology refers to the researcher's beliefs about the nature of reality (Cohen et al., 2013). The researcher understands the nature of gendered issues to be shaped over time and influenced by multiple factors: social, political and cultural, amongst others. Guba and Lincoln (1994) asserted that even though these structures are not real, they are taken as real. The researcher's educational background as a primary school teacher has been informed by social justice which relates to the transformational paradigm. The researcher sees education as a tool for amending false 'realities' that inhibit girls and women to a reality that allows equal access and space in which girls and women can develop a healthy mathematical identity. A constructivist paradigm was considered as the researcher views mathematical identity as an alterable construction (Guba & Lincoln, 1994). However, the transformational paradigm considers that there is a shift from imperfect realities towards an apprehendable and true reality. Teaching young children involves seeing their potential, and it is an idealistic hope of this researcher that limitations based on outdated notions of what girls can and cannot do will be removed in the near future. Looking at what exists and contrasting this to what is true can capture these beliefs (Killam, 2013). Relating this to a case study methodology is an authentic choice to capture the 'realities' as understood by the children, their parents and teachers in this case.

3.3.2 Epistemology

Epistemology identifies the relationship between the researcher and what is researched (Guba & Lincoln, 1994). The researcher's identity as a teacher observing other teachers in a community of schools meant that previously held notions of how schools work and how they transmit ideas about learner identity needed to be put to one side. This is so that the 'reality' of the case from the participants' perspective could be clearly viewed. For example, while it is the researcher's utmost hope that all teachers convey positive attitudes for all of their students and facilitate access and equity in their classrooms, to ensure trustworthiness and fidelity to the data, these values cannot be assumed. As suggested by Guba and Lincoln (1994), values by their nature are not absolute. They are subjective, and what participants believe to be 'knowledge' changes over time. The objective of this study is to capture the values of the participants authentically and without prejudice.

3.3.3 Axiology

The axiology in a transformative paradigm is considered the driver for the ontology, epistemology and methodology (Mertens, 2010). This study recognises that children are susceptible to persuasion from significant role models (Gunderson et al., 2012; Tomasetto et al., 2015). This is important for two reasons. First, it informs the basis for the research to explore the messages about mathematics that children are receiving from significant role models. The second reason is that the researcher needed to engage with the young participants with care to ensure their reality was captured authentically and without inadvertently guiding them towards a particular response. The researcher acknowledged a power dynamic during participant interviews with the Kindergarten children. To mitigate the effects of this power dynamic, the researcher was introduced as a teacher visiting to talk with the students about their thoughts on mathematics. In addition, the transformational paradigm asks whose voice is mirrored? (Guba & Lincoln, 1994). Therefore, it was important to capture the authentic voice of the child participants in this study and capture their reality faithfully.

3.3.4 Methodology

Mixed methods research has been called the “third research paradigm” (Johnson & Onwuegbuzie, 2004, p.15) and the “third methodological movement” (Tashakkori & Teddlie, 2003, p.5). It offers researchers an intuitive approach to “multiple ways of seeing and hearing” (Greene, 2007, p.20). The use of elements of quantitative and qualitative research approaches can also allow for a greater depth of understanding and corroboration than using either approach alone (Cohen et al., 2013). The rationale behind using a mixed methods approach in this current study is that there is an interest in both collecting responses from participants to understand a broad perspective (using quantitative methods) as well as understanding their responses in depth and being able to ask probing questions to explain why they have responded as they have (using qualitative methods). In doing so, there can be a more complete understanding ascertained.

This study utilised a mixed-methods approach employing both quantitative and qualitative methods. Onwuegbuzie and Leech (2005) suggest that the terms 'confirmatory and exploratory' research would more aptly describe the terms 'quantitative' and 'qualitative'. The premise of confirming and exploring data is certainly the intent of this study and so it seems appropriate in this instance at least. Reams and Twale (2008) build on this notion of mixed methods confirming and exploring the data and argued that mixed methods are "necessary to uncover information and perspective, increase corroboration of the data, and render less-biased and more accurate conclusions" (p.133). The mixed methods approach has also been referred to as pragmatism (Morgan, 2007; Yvonne-Feilzer, 2010). The pragmatic nature of this approach involves selecting the methods that are the most appropriate to the needs of the study. In this instance, drawing on both the numeric and narrative elements of the data express the data more completely (Denscombe, 2014). In addition, Denscombe (2014) highlighted the benefits of the mixed-methods approach compared to a single method, and stated that by utilising a mixed-methods approach, data accuracy can be increased. Additionally, mixed methods allow for a more complete picture of the case being studied which can overcome weaknesses inherent in a single method (Denscombe, 2014).

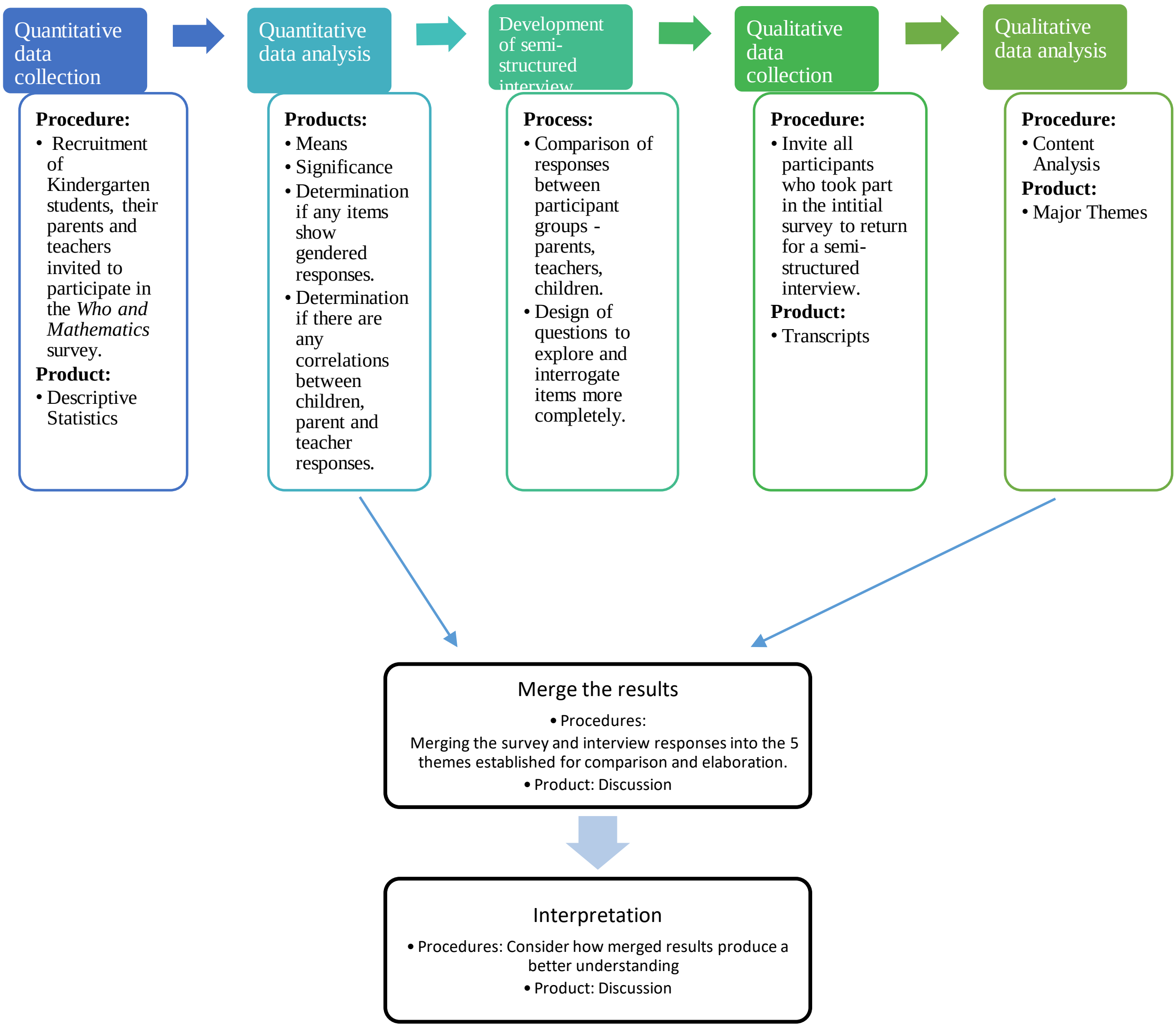
This mixed methods study addresses the overall aim of establishing how boys' and girls' mathematical identities are being informed as they begin school in Australia. A multiphase mixed methods design has been used in which sequential and concurrent collection of quantitative and qualitative data sets occurred over multiple phases of the study. In this study, the quantitative data, collected by the *Who and Mathematics* survey was used to establish the parents', teachers' and children's views of gender and mathematics identity. This data informed the next phase of the study, the semi-structured interview. The aim of the interview was to capture more in-depth data on the survey questions and allow participants to elaborate on their views. The rationale for collecting both quantitative and qualitative data is so that the data could emerge in each phase allowing the study to be responsive to the needs of the data. For example, the semi-structured interview questions were developed in response to the survey responses to understand unusual or intriguing participant responses. The study was carried out over a full year of Kindergarten, allowing the multiple phases to capture the shifting viewpoints over time.

The duration of the study allowed the changing perspectives of the children, as they developed a more informed experience of a school environment, to be captured.

In addition to using a mixed methods approach, there is also a multi-phase approach, which allowed the qualitative and quantitative elements to be utilised to their fullest. Initially, survey results were collected from participants and these data were analysed. This enabled a more careful consideration of questions for the semi-structured interview with parents to attempt to explain items that were unusual or intriguing. In this sense, the choice of mixed methods has been a pragmatic decision to utilise multiple methods to address the research questions. It combines inductive and deductive thinking to understand the case more fully. This process can be seen in Figure 3.1 which illustrates each step of the research process in this current study.

Figure 3.1

Overview of the multiple methods and multiple phases utilised.



Based on Wittink et al. (2006)

3.4 Case Study

Case studies emphasise relationships and processes and allow for a variety of types of data and research methods to be used (Denscombe, 2014). A case study also has the advantage of including interviews with participants to develop a deeper understanding of precisely what the participant's experiences are. The basis of this research is to identify *what* gendered mathematical beliefs are held and *how* they are being transmitted to children. Adelman et al.

(1980) claimed that case studies recognise social truths' complexity and 'embeddedness'. This aligns with the understanding of 'realities' inherent in the transformational paradigm. Adelman et al. (1980) also considered case studies to be a 'call to action' again making this methodology an authentic choice to align with the theoretical framework of critical theory and its central tenet of transformation. To understand children’s concepts and constructs of gender, it is important to understand the link to their parents’ views.

Employing a mixed-methods approach allowed a large pool of data to be collected through quantitative means. The qualitative method of semi-structured interviews allows for opportunities to ask questions and establish a dialogue with the participants. Quantitative methods are an authentic choice to identify these beliefs, with qualitative measures used to understand how they are communicated. Therefore, a mixed-methods case study is deemed the most appropriate and authentic choice to respond to the research questions within the frameworks of pragmatism, transformation and critical theory.

Stake (1995) viewed a case as a 'bounded system' that should inquire into the case "as an object, rather than a process" (p.2). Stake claimed the utility of a case study is the insight it provides into its complexity. He makes a point of considering the case's functions and the way its components work together. Merriam (1998) conceived of qualitative case study as "an intensive, holistic description and analysis of a bounded phenomenon" (p. xiii). Further, Merriam highlights the heuristic nature of case study in that it illuminates the understanding of the phenomenon being studied (1998). Where Stake (1995) and Merriam (1998) have provided valuable descriptions of the approach taken in this case study, it is Yin (2017) that provided the most helpful framework for its design. Yin (2017) suggested four types of design that researchers can utilise. These are single holistic design, single embedded design, multiple holistic design and multiple embedded design. This case utilises the single embedded design to capture multiple data sources from teachers, parents and children within the case to see how the components work together. In addition, the case employs multiple data collection instruments. This is for two reasons: the first is the intention to capture the 'what' and 'why' of the case. A survey is ideal for gathering large-scale information to uncover the 'what'. The 'why' can be revealed through an interview. The second reason for using multiple tools can be understood when the 'units of analysis' within the case are considered: parents, teachers, and children. The children need a different tool for data collection than the adults due to their limited ability to read and write, so a more suitable tool has been developed and implemented to ensure trustworthiness and fidelity.

3.4.1 Defining the Case

A fundamental consideration to any case study is the identification of the case (Yin, 2017). The single case study allows for an up-close and in-depth focus on the participants within the real-world context (Yin, 2017). The case in this study is the primary schools the students attend. The intended outcome is an authentic reflection of the school communities' beliefs, which provide the context as young learners develop their mathematical identity. This case study includes three schools, as a single case, that identify themselves as belonging to a 'community of schools'. In addition, the school populations, geographic location and socio-economic backgrounds are similar enough to be considered one case rather than multiple cases, as determined by the schools' Index of Community Socio-Educational Advantage (ICSEA) value assigned by the Australian Curriculum, Assessment and Reporting Authority (ACARA). The ICSEA value provides a numeric scale that quantifies the geographic location, parents' education and occupation and the proportion of Indigenous students (ACARA, 2013). Most schools sit in the median ranges of 500 to 1300, with the lowest values representing educational disadvantage and the higher values showing educational advantage. In 2018, when the data were collected, the three schools in this study had ICSEA values of 1005, 1037 and 1092. These values imply a closeness in educational advantage and context. It should be noted that this community of schools was not selected because of a particular feature, such as a notable mathematics program or focus on gender issues. Instead, the three schools were selected using convenience sampling as three schools with school principals that were supportive of allowing research to be conducted and in a geographical location the researcher could access. The selection of the schools was not purposeful, rather the researcher had access to these schools and they were considered fairly 'standard' public schools set in South-West Sydney.

This is an instrumental case study in that the schools were not chosen because there was something individual or idiosyncratic occurring there that warranted further attention. The research was not focused on particular teaching methods or populations. Rather, the schools were considered representative of general school communities and although care must be taken not to generalise case study results to wide populations, the intent was to look for gendered understandings and the way these are shared. The rationale is that if this can happen in one case, then it is something to be aware of in other cases and there are some principles that can be considered. Taber (2013, p.26) asserted that "sometimes (instrumental) cases are chosen because they are considered reasonably typical of a class of instances, where the complexity of what is being studied suggests more can be learnt by detailed exploration of an instant than surveying a representative sample.” The researcher hypothesises that the results from this case, while not being the same or generalisable to other cases, are still relevant to other cases as a means of learning about the way gendered messages can be shared, and as an issue they may want to explore within their own school community. By selecting the instrumental approach, this case study focuses on the results of this case, acknowledging that while results may be useful for sharing with other school communities, each school will have their own particular circumstances and idiosyncrasies that mean the results cannot be entirely generalised. Instead, their value lies in a prompt for discussion and reflection.

3.5 Methods of Data Collection

In this study, two methods of data collection were used. A survey and interview for parents and teachers, and a more child-friendly survey and an interview for the students. The advantage of the survey as a data collection tool is that it is more efficient at capturing data quickly and tends to be more reliable, due to its anonymity (Coher et al., 2013). The disadvantages of surveys are that questions need to be designed quite simply to avoid misunderstanding, which can garner superficial responses, and that participants with poor literacy levels can only participate in a limited way or may choose not to participate at all, leaving out a critical sub-group or 'voice' in the community (Cohen et al., 2013). This latter point was considered likely for the Kindergarten children participating in this study. This was mitigated by having an interview to address these concerns, which enabled the interviewer to address any questions or misunderstandings, delve into questions more profoundly and adjust the pace of the interview to suit the child.

3.5.1 Survey

Kindergarten parents at School A, School B and School C were invited to participate in the survey using the Skoolbag app. This survey was administered online using Google forms. The *Who and Mathematics* instrument (Leder & Forgasz, 2000) was used as the survey, which was designed to gauge gendered attitudes. It contains 30 items to gather information on gendered attitudes that can be used subsequently as data for analysis. Instructions and an example were included for the respondents to reduce errors and the risk of invalidated data (See Appendix D).

The survey was designed in such a way that parents and teachers were reminded if they missed an item and they were not able to submit the form until this was resolved, so that the problem of item non-response was avoided. Further, there were opportunities for the researcher to attend existing Kindergarten orientation evenings to introduce the study and herself and invite parents to take part in the survey at the same time. During the introductions, the researcher sent a link to the survey to potential participants. Cohen et al. (2013) asserted that response rates tend to increase when people are interested in the research, or it is made relevant to them in some way (Cohen et al., 2013).

3.5.2 The *Who and Mathematics* Instrument

In the past, the *Mathematics as a male domain* subscale of the *Fennema-Sherman Mathematics Attitude Scales* (Fennema & Sherman, 1976) was used to measure and document gendered attitudes and stereotypes. In 2000, Leder and Forgasz revised the *Mathematics as a male domain* instrument to allow for greater validity and to allow respondents to select an item as a female domain instead of the previous instrument, which only offered *male* or *neutral* options (Barkatsas et al., 2002). This revised instrument was called the *Who and Mathematics* instrument (Leder & Forgasz, 2000), which includes 30 items with statements such as: 'Mathematics is their favourite subject', 'Need mathematics to maximise future employment opportunities' and 'Expect to do well in mathematics'. Participants were asked to choose 1 of 5 possible responses on a Likert scale: boys definitely more likely than girls (BD), boys probably more than girls (BP), no difference between boys and girls (ND), girls probably more likely than boys (GP) and girls definitely more likely than boys (GD). To quantify these results and conduct statistical analysis, a value was assigned to each response, 1 to the BD response, 2 to BP, 3 to ND, 4 to GP and 5 to GD. Therefore, a mean score of <3 indicates an acceptance that 'boys are more likely to...' and a mean score >3 shows a belief that 'girls are more likely to…'.

The *Who and Mathematics* instrument provides a snapshot of perceptions of ability and aptitude and asks respondents to nominate which gender is more capable in certain aspects of mathematics. Leder and Forgasz (2000) validated this instrument using confirmatory factor analysis, confirmation of internal consistency and tests for correlation.

3.5.3 Development of the Child-friendly *Who and Mathematics* Instrument

In order to accurately gauge Kindergarten students' view of gender and mathematics, the *Who and Mathematics* instrument was revised as a child-friendly version. For example, during a pilot of the questions with Kindergarten students, it became clear that students' understandings of the term 'mathematics/ maths' at the beginning of the school year could be flawed. To address this, the term 'counting' was used instead. In addition, it could not reasonably be expected that students would be able to respond to questions relating to teacher behaviour when students have only just begun school. Any statements relating to classroom behaviour or personal study habits regarding mathematics were removed for this reason. The *Who and Mathematics* survey for children is listed alongside the parent version in Table 3.2, demonstrating alignment between the two versions of the survey.

Table 3.2

Alignment of the adult and child statements in the Who and Mathematics Survey

Adult Statement	Child Statement
1. Mathematics is their favourite subject	1. Maths/Counting and adding is their favourite thing to do
2. Think it is important to understand the work in mathematics	
3. Are asked more questions by the mathematics teacher	
4. Give up when they find a mathematics problem is too difficult	2. Which one will give up when they find a counting problem that is too hard?
5. Have to work hard in mathematics to do well	3. Which one will have to work hard at counting and numbers to get it right?
6. Enjoy mathematics	4. Which one would enjoy counting the most?
7. Care about doing well in mathematics	5. Which one would care the most about doing well in maths/ counting?
8. Think they did not work hard enough if do not do well in maths	
9. Parents would be disappointed if they do not do well in maths	6. Which one's parents would be sad or disappointed if they didn't do well in maths/counting?
10. Need maths to maximise future employment opportunities	7. Which one needs maths/counting when they grow up and get a job?
11. Like challenging mathematics problems	8. Which one likes it when maths and counting gets a little harder?
12. Are encouraged to do well by the mathematics teacher	
13. Mathematics teachers thinks they will do well	
14. Think mathematics will be important in their adult life	9. Which one thinks maths/counting will be important when they're grownups?

15. Expect to do well in mathematics	10. Which one expects that they will do well at maths/counting?
16. Distract other students from their mathematics work	
17. Get the wrong answers in mathematics	11. Which one gets the answers wrong in maths/counting?
18. Find mathematics easy	12. Which one finds maths and counting easy?
19. Parents think it is important for them to study mathematics	
20. Need more help in mathematics	13. Which one do you think will need more help in maths/ counting?
21. Tease boys if they are good at mathematics	14. Which one will tease other kids if they're not good at maths/ counting?
22. Worry if they do not do well in mathematics	15. Which one do you think will get worried if they're not good at maths/counting?
23. Are not good at mathematics	16. Which one isn't good at maths/ counting?
24. Like using computers to work on mathematics problems	17. Which one likes using computers to do maths/ counting?
25. Mathematics teachers spend more time with them	
26. Consider mathematics to be boring	18. Which one thinks maths/counting is boring?
27. Find mathematics difficult	19. Which one finds maths/ counting hard?
28. Get on with their work in class	
29. Think mathematics is interesting	20. Which one thinks maths/counting is interesting?
30. Tease girls if they are good at mathematics	14. Which one will tease other kids if they're not good at maths/ counting?

3.5.4 Recruitment

Candidates for this study were made up of Kindergarten students and their parents/ guardians and teachers. There should be a minimum of 30 students for statistical analysis, (Cohen et al., 2013). There were 78 child participants in this study (39 girls and 39 boys), 61 parents and 6 teachers. All Kindergarten parents were given hardcopy notes by their child's teacher and sent notes via the Skoolbag app to ask permission for their child to participate in the interview. In addition, the student participants were asked in the interview if they would like to participate. Parents were invited to attend the interview if they wished.

The parent survey was sent to all parents in the three schools via the Skoolbag app. Only parents of Kindergarten students were invited to participate. There were 300-600 potential participants parents and a 20% response rate expected. There were follow up messages sent to encourage participation by both mothers and fathers to equalise responses between the genders. The survey also invited parents to take part in a follow-up interview.

Teachers of the Kindergarten students were invited to participate via email with a link to complete the survey. There were eleven teachers in total and all were approached. Those who completed the survey were also able to participate in an interview.

The parameters of this sample were that students must be in Kindergarten and the parents interviewed must be parents of Kindergarten students. Teachers, similar to the rest of the population, can hold gendered views and ideas of student capabilities, which in turn could influence students' self-efficacy and conceptions of gender. The rationale was that Kindergarten students at the beginning of the school year are unique in that they have not yet had a great deal of time with their schoolteacher.

Equalising the sample to represent boys and girls in the student sample and mothers and fathers in the parent sample was important (Cohen et al., 2013). However, this was challenging for the parent survey as it is anecdotally more typical that mothers respond to notes and participate more readily in school requests. The mothers of the Kindergarten students were the main respondents and also made up the majority of the parent participants.

The total number of participants in each category can be seen in Table 3.3.

Table 3.3

Participation of parents, children and teachers

	Parents	Children	Teachers
Male	11	39	1
Female	50	39	5
Total	61	78	6

3.5.5 Site

The site of the research was the three primary schools, which are situated in South-West Sydney. There were approximately 80 Kindergarten students enrolled to attend School A, 120 students enrolled at School B, and 100 students enrolled at School C in 2018. The three schools are part of a 'community of schools', which comprises three primary schools and one high school. Teachers and executive staff have a collegial, working relationship between the four schools that make up this community. The fourth school in this community is a high school and was therefore not included in this study.

As discussed earlier, consideration was taken as to whether this was a single or multiple case study when defining the case. Based on objective measures such as the very close ICSEA values of each school, the indication was that these schools share similar family backgrounds. In addition, the close geographical location of each of the three schools meant the Kindergarten participants all attended pre-schools in the area together before starting school. This trend continued with families from the three schools being part of the same community in sporting and dance groups and social activities. Anecdotal evidence suggest that the schools were considered to be fairly similar in that there is not a school that is considered more desirable to attend than the others. All three schools are Department of Education (i.e public) schools. The only notable difference is that School C has an opportunity class on-site. This is for Year 5 – 6 students who have excelled academically and met the state-wide selection criteria in an exam. These students typically enrol from out of the area, and there is no advantage given to students already attending the school in earlier years. Therefore, in this case, School C is still be viewed as similar to the other two schools and the sample population for this study are not impacted.

3.5.6 Interviews

Both parent and student interviews followed a 'semi-structured interview' format. Lichtman (2013, p. 190) qualified that the intent of an interview is "to set up a situation in which the individual being interviewed will reveal to you his or her feelings, intentions, meanings, sub-contexts, or thoughts on a topic, situation, or idea". The interview emphasises the 'social-situatedness' of research data and acknowledges that data captured in this format is constructed between the participants (Laing, 1967). Utilising the interview format in addition to collecting quantitative data in the earlier survey tool demonstrates an intent to understand the interconnections between the participant, their responses and their context. This is an appropriate choice given the theoretical view that gender and identity constructs are formed in relationship to multiple social and cultural contexts. An interview can get to the heart of the participant's construction of these beliefs.

The interview location was the school the parents and students were familiar with to make attendance more likely and to ensure they felt comfortable. The interviews were held in a quiet room, without interruptions. During the interview, the interviewee was made aware that notes and an audio recording would be taken to document their responses. Responses were prompted, probed and checked to ensure the precise meaning was captured in the interviewee's responses (Denscombe, 2010).

3.5.7 Parent Interview

The participants interviewed included all parents who indicated in the survey that they would be willing to take part in the follow-up interview. In total, there were 61 parents that opted-in for the interview (50 mothers and 11 fathers).

The *Who and Mathematics* survey conducted prior to the interview provided a snapshot of parent views. An interview was then conducted to gain a more precise and more detailed picture from parents to capture their understanding and the reasoning behind their beliefs. Interview questions were directed to the participants' own experiences, feelings, beliefs and observations about mathematics and gendered ability. Importantly, relating the interview cohesively to the responses from the survey took advantage of the case study framework and ensured it was an integrated research rather than just a series of parallel studies (Yin, 2006).

Interview questions were informed by both the responses to the *Who and Mathematics* survey and the literature (see Appendix G). This was intended to be responsive to the data captured in the survey, explore relevant responses more thoroughly and allow for further clarification. There was a clear list of questions to be addressed, although the semi-structured format provided the interviewer with the flexibility to prompt the interviewee to expand on their ideas and elaborate or clarify points of interest (Denscombe, 2010). King et al. (2018) outlined three types of probes that can be useful in interviews to gain insight, ensure accuracy and gain a fuller response in a situation where the respondent might not be expressing their thoughts clearly. Table 3.4 shows some examples of the use of these prompts in this study.

Table 3.4

Examples of probing from the interview transcripts of this study

Type of Probe	Example from Interview
Elaboration	Researcher: Would you consider yourself to be good at maths? Respondent: No. Basic maths, yes, but nothing too extensive. Researcher: Okay. How do you know that?
Clarification	Respondent: Yeah 'cause as I said the four kids I have, I haven't really seen that at all, they're all good at their certain things and they don't really play off each other. Researcher: So, when you were responding to the survey, were you thinking about it through the eyes of your children? Respondent: Yeah 'cause they're the only eyes I probably have. Researcher: Yes, so you weren't thinking back to your experiences in high school, you were more thinking about your kids. Respondent: Yeah, that's right.
Completion	Researcher: Was there anything that you were thinking? Respondent: It's just my experience. It's like, of, you're going to pass off, your whole degree is relied upon maths. It's kind of like, you'll fail everything, it doesn't matter how great you are at everything else, if you fail this one thing. Researcher: So that experience has really coloured how you feel- Respondent: Absolutely. Because I didn't mind maths before. Yeah, I actually enjoyed maths and I quite enjoyed it, if they say, "Oh look you did this" but in nursing it's like, "You'll kill someone if you don't"

3.5.8 Student Interview

The student interview was completed in the first fortnight of Term 1 and again at the end of Term 4. There were initially 78 child participants (39 boys and 39 girls in Term 1). This adjusted to 35 boys and 37 girls in Term 4 due to students leaving their schools or extended holiday leave during the interview period. These statements were taken from the *Who and Mathematics* instrument and modified for Kindergarten students to understand (See Appendix E). Only statements that related to their early experiences of mathematics and school were included. For example, items regarding future employment or classroom behaviours of teachers and students were omitted. Although this has been categorised as a semi-structured interview, it could be considered an assisted survey. It was expected that Kindergarten students would be unable to read or write efficiently enough to understand and respond to the written questions. Therefore, the researcher read the questions and completed the survey on the student's behalf. This allowed the researcher to ensure the student had comprehended the question accurately and completed the survey appropriately. It also allowed the researcher to probe their responses if required. Children completed the interview in a quiet place alongside or near their classroom. Using three picture cards of a boy, a girl and both genders to represent the response that boys would be more likely to meet this descriptor, girls would be more likely to meet this descriptor or the card with both a boy and a girl for no difference (See Appendix F). To ensure that students understood this method of representing their response, an initial trial question was given to them 'Who would you say is more likely to enjoy the movie *Frozen*?' Students were able to select the card that represented their perspective and the researcher could ensure that they understood how to respond before the survey formally began. After each question and corresponding card choice, the children were asked to explain their reasoning and their own experiences. These interviews were conducted in the first weeks of the school year and again at the end of the school year to evaluate any changes in response as a result of attending school.

3.6 Methods of Data Analysis

3.6.1 Quantitative Data Analysis

Surveys were checked for three main things: completeness, accuracy and uniformity (Cohen et al., 2013). Data from the surveys were de-identified and processed using Microsoft Excel 2016. Parents' and teachers' response to the surveys were converted into numerical values from –2 to +2, such that 0 would signify that there is no difference. In other words, the response 'boys definitely' was converted to –2, 'boys probably' to –1, 'no difference' to 0, 'girls probably' to +1 and 'girls definitely' to +2. The data was then imported into IBM SPSS Statistics version 27 to calculate the mean, standard deviation (SD) and *p*-value. For the latter, an unpaired *t*-test was used to determine statistical significance. A p-value <0.05 was considered statistically significant. Graphs were created using Microsoft Excel 2016.

Reliability of the collected data was established by checking and re-checking the data sets as they were being analysed. Once the scores were converted to the range –2 to +2, the scores were checked again and compared to the raw scores for accuracy. Any anomalies were also checked to ensure accuracy. In addition, given the grouping of the data into categories, it was apparent when data in one statement was incongruous with another. For example, if the data showed participants determined that girls are more likely to be good at mathematics at the same time as showing that participants thought girls are less likely to care about mathematics, then the first process was to check the accuracy of the data to ensure internal consistency.

3.6.2 Qualitative Data Analysis

In this case study, the initial data collection method was the *Who and Mathematics* instrument (adult and child versions) completed by the children, teachers and parents as a survey. Follow-up interviews with parents and children provided additional insights to explain and elaborate on survey responses. Content analysis on the interview responses has allowed for a focus on the language used by participants with close attention paid to both the content and context (Tesch, 1990). This means that in addition to counting words for content, by examining the language used, associations and context has been obtained. While content analysis is a method in its own right (Hsieh & Shannon, 2005) in this instance, its value was in addressing the weaknesses inherent in collecting data only through quantitative means. Using content analysis allowed a more thorough interrogation of the qualitative interview data and was used to explain particular responses that were puzzling or unexpected. An example of its utility occurred in the responses to the survey from participants regarding the importance of mathematics to maximise employment opportunities. Respondents thought this was more important for boys than girls. By probing participants further in the interview about their thoughts on why this might be, and then conducting content analysis on the responses, it became clear that many participants still relate certain types of employment to males or females and that 'male' employment is more likely to require mathematics. This insight would not have been realised without the utilisation of the interviews and qualitative analysis.

The qualitative data in this case study was collected through semi-structured interviews. This allowed the researcher to probe responses and ask for more information or to explain the rationale for the response. The parent interviews were transcribed from audio recordings and read through several times to achieve ‘immersion’ and notice any patterns in words, phrases or ideas that were repeated. Tesch (1990) explains that achieving immersion in the data allows for a greater sense of the whole. A basic count was taken of these patterns and noted as a potential category. For example, ‘high stakes testing’ was referred to 12 times by the seven parents. In addition, each time it was mentioned, it was always in relation to enjoyment or anxiety about mathematics, which were two other themes that surfaced. By highlighting and counting the frequency of concepts across the data set, 17 themes emerged and were coded. These were placed into a concept map, and an additional count occurred to establish relationships between themes (Appendix H). For example, if a respondent referred to the idea of mathematical success, it was noted if they connected this idea to another theme, such as, enjoyment of mathematics. In this way, context was able to be established. This also relates back to the intent of the study which involves the relationships in a school setting and the way in which different interactions can inform a child’s mathematical identity. For example, parent participants often related the questions back to their own education and school experiences rather than their child’s. This showed that some concepts were developed 20 years earlier and may not be accurate, or as relevant to the current study. However, because this was the parent’s construct, they were sharing it with their child and modelling an approach to school and learning that was outdated, and that was important to know in this study.

Finally, concepts were then clearly defined and named. They were also compared with the data analysis conducted on the *Who and Mathematics* instrument responses to look for patterns between the two forms of data. In doing so, the themes emerging from the parent interview were utilised in the results chapters alongside the survey data to elaborate and elucidate participant viewpoints.

To ensure accuracy of the qualitative data, participants were shown their survey results to confirm their responses. In addition, member checking was conducted with transcripts shown to participants so they could consider whether this was an accurate and trustworthy reflection of their thoughts (Cresswell & Plano Clark, 2011).

3.6.3 The Student Interview

The student interview contains both quantitative and qualitative elements. The student's response with the card had only three choices (boys, girls, both). These responses were made numeric. ‘Male’ was assigned –1, ‘female’ was assigned +1, and ‘’both/ no difference’ was assigned 0. This data set was analysed quantitatively as described in Section 3.6.1. The researcher also asked students to elaborate on their responses and collected qualitative data as the survey was completed. This was not analysed using content analysis. For most of the children, at this age, and with an unfamiliar adult, there was not a great deal of dialogue to be captured. However, some students did share some interesting thoughts and comments, which were reported as quotes to elaborate on the quantitative data collected. The student interview was conducted twice. The first interview was in the first few weeks of school Term 1 and the second interview was in the final few weeks of school Term 4. In this way, the researcher was able to compare responses from individual participants and compare the data sets from each interview to establish changes in perspective.

3.7 Ethical Considerations

Following approval from the University of Notre Dame Australia Human Research Ethics Committee in May 2017 (Reference No. 017005S), permission was sought and received from the NSW Department of Education State Education Research Applications Process (SERAP) to complete research within government schools (SERAP No. 2016629). Following these approvals, school principals were contacted via email to seek permission to conduct interviews with Kindergarten teachers, students and their parents. The principals of the three schools were sent information regarding the purpose and scope of the study and the participant information sheets and consent forms (Appendices A-C). All participants and the schools were de-identified, as anonymity was an integral part of the ethical approval process.

Importantly, there needed to be consent to take part, as well as the ability to withdraw at any time, for any reason. The students, parents and teachers involved were required to indicate their understanding that the survey and interview were intended to generate responses that would be used for research purposes and were ‘on the record’ (Denscombe, 2014). For the students, their parents signed consent forms on their behalf. In addition to this, the researcher asked each child participant if it was “okay to ask questions about what they think about mathematics” and also, “okay to record these questions using a recording device?” In this way, children were given the ability to decline the interview process. Adult participants were also invited to check the transcripts for accuracy and offered access to the thesis once completed.

3.8 Summary

The purpose of this chapter was to rationalise the choices made throughout this study concerning the mixed methods method chosen, utilising the pragmatic worldview, with an axiological focus on social justice in a multiphase design and the subsequent methodological steps the research followed. The chapter also described the development of the *Who and Mathematics* child friendly survey as an addition to the existing *Who and Mathematics* instrument designed by Leder and Forgasz in 2000. Furthermore, the chapter outlined how this mixed-methods approach utilised surveys and semi-structured interviews to take advantage of numeric and narrative representations of the data. Finally, this chapter described how the study, the theoretical framework and methodology connect.

Chapter Four: Presentation of Research Findings from Parents

4.1 Overview

The focus of this chapter is to present responses related to the first part of the research sub-question: *What are parents' and teachers' views of girls' and boys' mathematical identities?* The second part of the research sub-question to do with teachers will be dealt with in Chapter Six. This chapter will present the parents' views on gender and mathematics through their responses to the *Who and Mathematics* survey (Leder & Forgasz, 2000). Data from a follow up semi-structured interview conducted with parents are also presented to provide insight into parents' responses to the *Who and Mathematics* survey.

This chapter is organised into two sections. Section one will evaluate whether there was a statistical difference between fathers' and mothers' responses to the 30 statements in the *Who and Mathematics* survey. The second section will review the overall perspective of parents' responses to the survey, noting where responses tended towards mostly boys or mostly towards girls. These data were then grouped into:

1. Statements that parents are more likely to associate with girls
2. Statements that parents are more likely to associate with boys
3. Statements where parents think there is no difference between boys and girls

Statements within these three groups were subdivided into themes to further assess parents' overall views on gender and mathematics. Finally, the statements from the *Who and Mathematics* survey were evaluated as being positive or negative to further measure whether parents' perceptions were positively or negatively associated with the themes established in the survey.

Table 4.1

Overview of Chapter Four: Presentation of Research Findings from Parents

4.1	Overview
4.2	4.2.1 Comparing Fathers' and Mothers' Response to The *Who and Mathematics* Survey 4.2.2 Parents' Perspectives on Gender and Mathematics
4.3	Summary

4.2.1 Comparing Fathers' and Mothers' Response to the *Who and Mathematics* Survey

For this section of the study, 61 parents responded to the *Who and Mathematics* survey, comprising 11 fathers and 50 mothers. Across all questions in the survey, the most common response from parents was that there is no difference between boys and girls in mathematics. In order to quantify the data, survey responses submitted on a five-point Likert scale were converted into numerical values from –2 to +2. This is a deviation to the way the *Who and Mathematics* instrument was analysed by Leder and Forgasz (2000) who allocated values from 1 - 5. The reason for this modification was to make clear that the value zero meant 'no difference'. A deviation to the left (i.e. negative values) indicated a response towards boys and to the right (i.e. positive values) indicated a response towards girls. Specifically, the response 'boys definitely' was assigned –2, 'boys probably' with –1, 'no difference' with 0, 'girls probably' with +1 and 'girls definitely' with +2.

When the mean results were reviewed, these showed that parents tended to believe that girls or boys demonstrated particular capabilities and beliefs in mathematics. In order to determine whether the gender of parents was an influencing factor in their responses to the *Who and Mathematics* survey, the mean and standard deviation to each of the statements in the survey was assessed. The data show that of the 30 statements in the survey, parents of both genders rated similarly, and a statistical significance was only apparent in five statements (Table 4.2). These statements were:

- Statement 1: Mathematics is their favourite subject
- Statement 9: Parents would be disappointed if they do not do well in maths
- Statement 22: Worry if they do not do well in mathematics

- Statement 25: Mathematics teachers spend more time with them
- Statement 29: Think mathematics is interesting

Table 4.2

Comparison of fathers' and mothers' responses to the Who and Mathematics survey

Statement	Fathers' mean (n=11)	Fathers' SD (n=11)	Mothers' mean (n=50)	Mothers' SD (n=50)	P-value	Statistical significance
1	-.727	.786	-.220	.648	**.027**	*
2	-.364	.809	-.060	.712	.216	
3	-.455	.688	-.160	.510	.109	
4	.091	.539	-.300	.707	.090	
5	.000	.447	.060	.586	.751	
6	-.182	1.250	-.120	.689	.820	
7	.091	1.221	.220	.790	.660	
8	-.091	.831	.320	.713	.098	
9	-.545	1.036	-.020	.428	**.008**	**
10	-.091	.944	-.180	.661	.710	
11	.000	.894	.100	.839	.725	
12	-.091	.302	-.060	.586	.866	
13	-.091	.944	.020	.622	.630	
14	-.182	.751	-.280	.671	.669	
15	.000	.775	.140	.729	.570	
16	-.273	.647	-.500	.735	.348	
17	.091	.302	-.080	.396	.184	
18	-.182	.405	.040	.570	.227	
19	-.182	.603	-.160	.548	.907	
20	.182	.405	.040	.669	.503	
21	-.273	.786	-.140	.729	.592	
22	-.455	.934	.360	.749	**.003**	**
23	.091	.302	.060	.512	.848	
24	-.273	.905	-.060	.620	.349	
25	-.364	.809	.060	.512	**.030**	*
26	.182	.603	-.080	.665	.235	
27	.182	.405	.040	.605	.462	
28	.455	.522	.420	.785	.890	
29	-.545	.688	-.040	.605	**.017**	*
30	-.273	.786	-.160	.817	.678	

*$p < .05$, **$p < .01$.

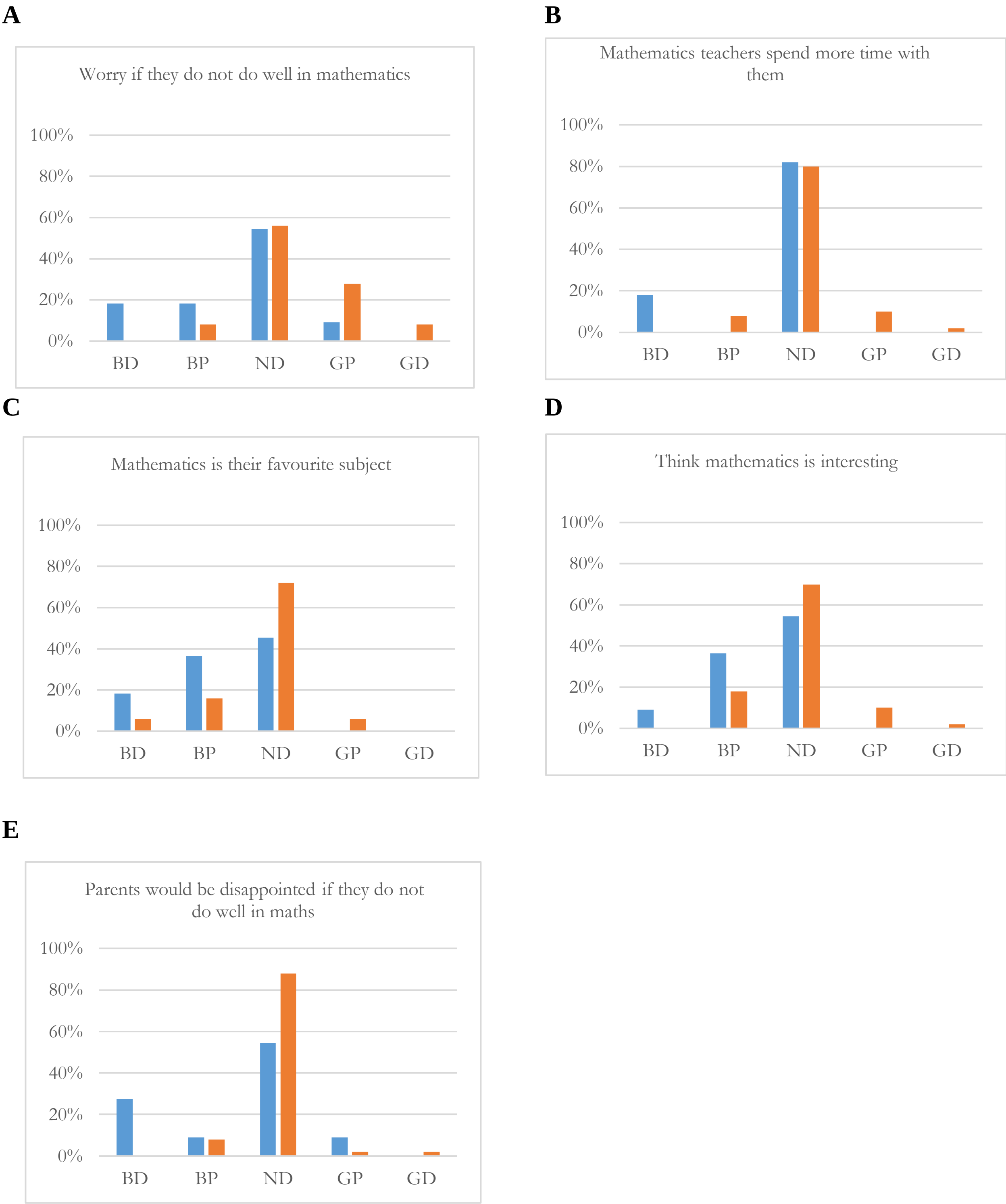
Curiously, of these five statements that showed a statistically significant difference in the mean response between parents' gender, only two showed an opposing view (statements 22 & 25). In statement 22, parents were asked who would *worry if they did not do well in mathematics*. The mean response from fathers tended towards boys and mothers towards girls (Figure 4.1A). Specifically, 36% of fathers thought boys would worry more if they did not do well in mathematics, while only 9% thought that girls would worry about their mathematical performance. In contrast, 36% of mothers believed that girls would worry about not doing well in mathematics, with only 8% thinking the boys would worry. When parents were asked to elaborate on this, one of the participants Mother D said "I think in general, from my personal experience, the girls seem to worry a bit more about marks and perfecting, getting the right answer, whereas the boys were more sort of practical, and sort of easy going towards maths." One of the other participants, Mother B agreed that girls were more likely to worry about mathematics and described the conversations she had with her children after school "Yeah. Because when she comes home and she tells me, oh, I didn't do good. I should have done this and that, but with (my son), like, he's like, it's alright, I can do better next time."

Similarly, in statement 25, when parents were asked whether *mathematics teachers spend more time with them*, fathers were more likely to select boys, and mothers were more likely to select girls (Figure 4.1B). Amongst the fathers, 18% believed that teachers definitely spend more time with boys. Although 8% of mothers thought teachers would probably spend more time with boys, 12% believed girls receive more teacher attention.

When asked for whom *mathematics is their favourite subject* (statement 1) or who *thinks mathematics is interesting* (statement 29), parents of both genders chose boys, with a higher percentage of fathers selecting boys probably and boys definitely in both questions. As a point of interest, no father thought that girls would consider mathematics as their favourite subject or find it interesting (Figure 4.1C & D). While there was a tendency to select boys for these statements, most mothers felt that there was *no difference*. When asked whether it would be boys' or girls' *parents (*who*) would be disappointed if they do not do well in maths* (statement 9), parents were more likely to select boys' parents, which was more apparent with fathers (36%) compared to mothers who were more likely to think that it was neutral (Figure 4.1E).

Figure 4.1

Statements in the survey where fathers' and mothers' views differ.



Note. Blue columns represent fathers (n=11). Orange columns represent mothers (n=50). BD = boys definitely, BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

4.2.2 Parents’ Perspectives on Gender and Mathematics

Since the response for most statements did not show a statistically significant difference between parents’ gender, further analysis combined mothers’ and fathers’ views into a single category of parents. In doing so, it was found that the mean response for all statements was between -0.46 and 0.43, which indicates that parents’ responses were mostly *no difference*. In addition, parents’ mean responses tended towards girls for 10 of the 30 statements, boys for 18 statements and neutral for two statements (Figure 4.2).

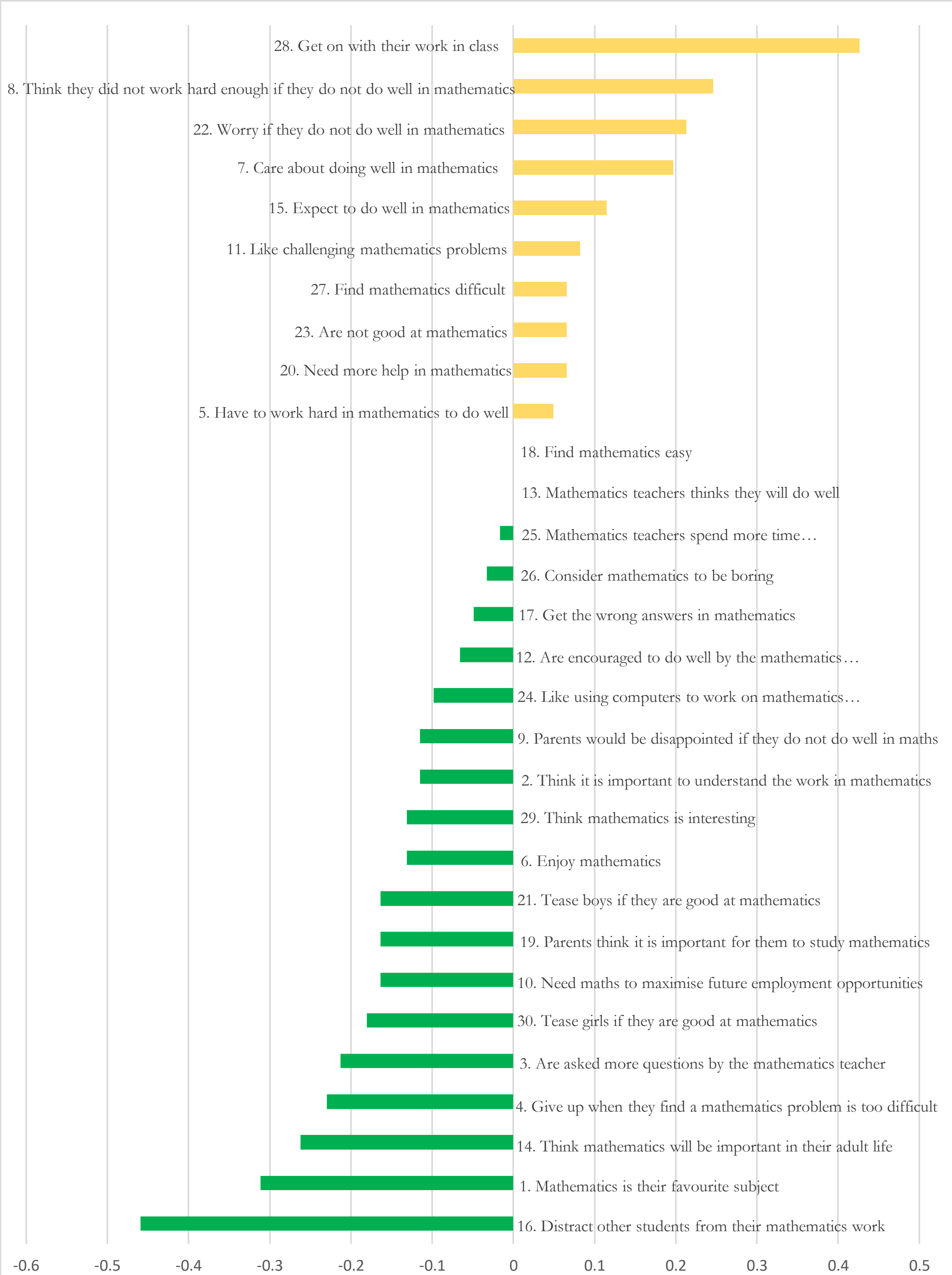
Further analysis explored the tendencies of responses towards girls or boys to understand some of the more subtle parent biases. Within these data, the strongest response to statements towards either boys or girls is associated with behaviour in the classroom (Figure 4.2). The two statements with the highest mean were related to parents’ views of girls as hard workers with a mean of 0.43 for the statement *gets on with their work in class* while they perceived the opposite for boys with results showing a mean of –0.46 for the statement *distracts other students from their mathematics work*. One of the participants, Mother B elaborated on this notion in the follow-up interview when she said “Yeah. Girls, they want to ... I know they're more focused especially with maths.” When asked by the researcher why she thought this, Mother B said “Just they (boys) didn't listen that much maybe…Their listening, yeah…Like, because they're more distracted.”

Parents’ mean responses were neutral for the statements *mathematics teachers think they will do well* and *finds mathematics easy*, with a mean of 0 for both statements. Interestingly, the opposing statement *finds mathematics difficult* was a statement that parents associated more with girls (Figure 4.2). Given that the mean for this statement was 0.066, parents’ perception that girls find mathematics difficult is only marginal. During the follow-up interview, Mother C elaborated on this:

> Well, I don't believe gender of a person does determine how clever they are with regards to mathematical equations. I believe it's how they've been taught at home and what they've been exposed to, in their environment and how they can tackle, not tackle it, come to a question like a mathematical equation and try and have an answer. I don't think gender has anything to do with it.

Figure 4.2

Parents' mean response in the Who and Mathematics Survey.



Note. Yellow bars represent parents' views towards girls and green bars represent parents' views towards boys.

4.2.2.1 Categorisation of the *Who and Mathematics* Statements into Themes

To further understand parents' perceptions of gender and mathematics, statements from the *Who and Mathematics* survey were analysed and categorised into themes. This process was used by Leder and Forgasz (2000) to categorise the statements in the *Mathematics as a Gendered Domain* survey instrument, which is a revision of one of the scales (Mathematics as a Male Domain) in the commonly used Fennema-Sherman Mathematics Attitude Scales. Following this process, each statement from the *Who and Mathematics* survey was carefully reviewed and assigned a keyword that summarised the statement's intent. This enabled the evaluation of whether parents held general views about gender and mathematics that influenced their response across a range of statements in the *Who and Mathematics* survey.

Within this analysis, statements that were related to one another were grouped into themes. For example, the statements *are not good at mathematics* and *need more help with mathematics* have been categorised as statements relating to mathematical aptitude. In Table 4.3, each of the thirty statements was assigned a theme. The following five themes were used to summarise the 30 statements:

- Self-concept (11 statements)
- Aptitude (6 statements)
- Encouragement from role models (6 statements)
- Enjoyment (5 statements)
- Relevance to later life (2 statements)

Self-concept

For the purpose of cohesion, self-concept has been defined from the literature "a person's self-perception in mathematics… shaped by one's experience with the environment and significant others." (Niepel et al., 2019, p. 1120). Some of the statements included in this theme also consider application in mathematics as an indication that the student values the subject. Two statements may initially appear out of place here. These are related to teasing boys and girls if they are good at mathematics. While these are behavioural, they are related to feelings of insecurity about personal competence and so, have been included in the theme of *self-concept*.

Aptitude

Aptitude has been defined simply as an acquired or natural ability to achieve in mathematics. Any statement relating to success and achievement (or lack thereof) in mathematics has been labelled as belonging in *aptitude*.

Encouragement from Role Models

In the *Who and Mathematics* survey, several statements relate to the interest and support students receive from their parents and teachers. For example, this could be considered positive when teachers engage a particular gender more in mathematics lessons, or there could be an increased expectation from parents that they do well in mathematics, depending on their gender. For this study, any statement relating to the way that parents and teachers may influence a students' self-concept about mathematics has been classified as belonging to the theme *encouragement from role models.*

Enjoyment

Enjoyment is linked to interest and enjoyment in mathematics and finding the subject stimulating and engaging. Any statements discussing mathematics as interesting, enjoyable or a favourite subject has been included in the theme of *enjoyment.*

Relevance to Later Life

Any statements to do with mathematics as important in adulthood for personal capability or employment was included in the theme *relevance to later life.*

Categorised statements can be seen in Table 4.3 showing the theme selected for each individual statement.

Table 4.3

Themes for the Who and Mathematics Statements

Statement	Theme
1. Mathematics is their favourite subject	Engagement
2. Think it is important to understand the work in mathematics	Self-concept
3. Are asked more questions by the mathematics teacher	Encouragement from role models
4. Give up when they find a mathematics problem is too difficult	Self-concept
5. Have to work hard in mathematics to do well	Aptitude
6. Enjoy mathematics	Engagement
7. Care about doing well in mathematics	Self-concept
8. Think they did not work hard enough if do not do well in maths	Self-concept
9. Parents would be disappointed if they do not do well in maths	Encouragement from role models
10. Need maths to maximise future employment opportunities	Relevance to later life
11. Like challenging mathematics problems	Self-concept
12. Are encouraged to do well by the mathematics teacher	Encouragement from role models
13. Mathematics teachers thinks they will do well	Encouragement from role models
14. Think mathematics will be important in their adult life	Relevance to later life
15. Expect to do well in mathematics	Self-concept
16. Distract other students from their mathematics work	Self-concept
17. Get the wrong answers in mathematics	Aptitude
18. Find mathematics easy	Aptitude
19. Parents think it is important for them to study mathematics	Encouragement from role models
20. Need more help in mathematics	Aptitude
21. Tease boys if they are good at mathematics	Self-concept
22. Worry if they do not do well in mathematics	Self-concept
23. Are not good at mathematics	Aptitude

24. Like using computers to work on mathematics problems	Engagement
25. Mathematics teachers spend more time with them	Encouragement from role models
26. Consider mathematics to be boring	Engagement
27. Find mathematics difficult	Aptitude
28. Get on with their work in class	Self-concept
29. Think mathematics is interesting	Engagement
30. Tease girls if they are good at mathematics	Self-concept

4.2.2.2 Positive and Negative Associations in the *Who and Mathematics* Survey

In addition to examining parents' perceptions of boys' and girls' relationship with mathematics, understanding whether these views are positive or negative helps to see whether parents are associating positive or negative perspectives to one or both genders. This is an additional layer of analysis compared to the original Leder and Forgasz research using the *Who and Mathematics* instrument (2000; 2002).

To determine which of the *Who and Mathematics* statements could be considered positive or negative, each statement was allocated a positive or negative value in relation to the implication of the students' relationship to mathematics (Table 4.4). For example, the statement *is not good at mathematics* is demonstrably negative. While many of the statements were relatively straightforward to assign a value, some statements were indeterminant as they could be understood to have multiple meanings. For example, the statement *Are asked more questions by the mathematics teacher* could mean that the mathematics teacher is either concerned, interested, or delighted by the students' possible responses. So, in these instances, these were considered neither positive nor negative statements. There are four of these statements:

- *Like using computers to work on mathematics problems.* This could be more related to personal interests rather than mathematical competence.
- *Are asked more questions by the mathematics teacher.* While it could be seen as positive that the teacher is engaging more with the student, it is ambiguous whether or not this is because the student needs extra assistance.
- *Are encouraged to do well by the mathematics teacher.* Again, this is a positive experience but because the statements were evaluated in relation to perception about

the students' capabilities, it cannot be certain that the teacher is being encouraging because the student needs extra support or is excelling.

- *Mathematics teachers spend more time with them*. Similar to the other statements related to the mathematics teacher and their interactions with their students, it cannot be established whether this behaviour results from the students' poor or strong aptitude in the subject.

By adding this layer of analysis, the parents' views can be grouped into related themes and assigned a positive or negative connotation (Table 4.4). For example, the statements showing parents' views relating to girls and self-concept are mostly positive, with four out of the six statements considered positive while the remaining two statements are neither positive nor negative. Therefore, it could be considered that parents view girls' mathematical self-concept positively overall. The opposite is true when the statements aligned with girls' mathematical aptitude are considered. Out of the four statements, all four are thought to be negative. So, an interpretation of the parents' perceptions of girls' relationships with mathematics can be drawn, that they consider girls hard workers but without natural talent. This will be further explored by analysing each of the five themes in turn.

Table 4.4

Who and Mathematics statements assigned a positive (+), negative (–) or neither value (+/–)

Statement	Value
1. Mathematics is their favourite subject	+
2. Think it is important to understand the work in mathematics	+
3. Are asked more questions by the mathematics teacher	+/–
4. Give up when they find a mathematics problem is too difficult	–
5. Have to work hard in mathematics to do well	–
6. Enjoy mathematics	+
7. Care about doing well in mathematics	+
8. Think they did not work hard enough if do not do well in math	+/–
9. Parents would be disappointed if they do not do well in maths	+

10. Need maths to maximise future employment opportunities	+
11. Like challenging mathematics problems	+
12. Are encouraged to do well by the mathematics teacher	+/–
13. Mathematics teachers thinks they will do well	+
14. Think mathematics will be important in their adult life	+
15. Expect to do well in mathematics	+
16. Distract other students from their mathematics work	–
17. Get the wrong answers in mathematics	–
18. Find mathematics easy	+
19. Parents think it is important for them to study mathematics	+
20. Need more help in mathematics	–
21. Tease boys if they are good at mathematics	–
22. Worry if they do not do well in mathematics	+/–
23. Are not good at mathematics	–
24. Like using computers to work on mathematics problems	+/–
25. Mathematics teachers spend more time with them	+/–
26. Consider mathematics to be boring	–
27. Find mathematics difficult	–
28. Get on with their work in class	+
29. Think mathematics is interesting	+
30. Tease girls if they are good at mathematics	–

4.2.2.3 Parents' Responses to the *Who and Mathematics* Survey Categorised into Gendered Themes

The themes assigned to each of the 30 statements in the survey (Table 4.3) afforded the opportunity to evaluate whether parents' perceptions in Section 4.2.2 associated a particular gender with specific attributes. This was achieved by grouping statements by their assigned themes and dividing them into two groups, based on whether parents' mean responses tended towards girls or boys. In order to better understand the gendered beliefs that parents hold about boys' and girls' relationship with mathematics, each of the five themes were individually analysed.

4.2.2.3.1 Parents' Perceptions of Gender and Self-concept Towards Mathematics

Of the 11 statements relating to self-concept and mathematics, six were associated with girls and five with boys (Table 4.5).

Table 4.5

Parents' perception of gender and self-concept towards mathematics

	Statement	Parents' mean (n=61)	Value
Statements that parents attributed more to girls	Get on with their work in class	.426	+
	Think they did not work hard enough if do not do well in maths	.246	+/–
	Worry if they do not do well in mathematics	.213	+/–
	Care about doing well in mathematics	.197	+
	Expect to do well in mathematics	.115	+
	Like challenging mathematics problems	.082	+
Statements that parents attributed more to boys	Distract other students from their mathematics work	-.459	–
	Give up when they find a mathematics problem is too difficult	-.230	–
	Tease girls if they are good at mathematics	-.180	–
	Tease boys if they are good at mathematics	-.164	–
	Think it is important to understand the work in mathematics	-.115	+

Overall, the statements that parents associated with girls and mathematical self-concept were positive. Parents viewed girls as having a diligent work ethic with high personal expectations of achievement. The data show that 13% of parents believe that girls *expect to do well in mathematics* (Figure 4.3A) compared to 11% of parents selecting this as a characteristic held by boys. Parents also thought that girls (32%) were more likely than boys (13%) to *worry if they do not do well in mathematics* (Figure 4.3B). Four times (33%) as many parents thought that girls would attribute lesser achievement to their lack of effort (Figure 4.3C) compared to boys (8%). In addition to worrying more about results, girls were nominated by parents as being more diligent when they consider who *gets on with their work in class* (Figure 4.3D).

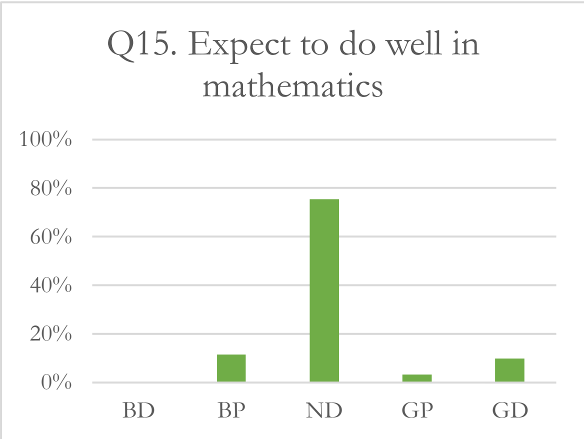
Parents were more likely to think that girls (38%) have a strong work ethic than only 5% of parents who believe it to be a characteristic of boys. Parents felt that girls were more likely to *like challenging mathematics problems* (Figure 4.3E), with 8% of the parents believing that girls definitely would enjoy the challenge of demanding problems compared to 2% who felt this definitely applied to boys. More than double the number of parents (28%) believe that girls rather than boys *care about doing well in mathematics* (Figure 4.3F). Parents appear to have a favourable view of girls as diligent students who enjoy challenges and expect success.

Out of the statements that parents felt were more likely to be applied to girls, four were identified as positive views of girls' attitudes to mathematics (Table 4.5). The two remaining statements (*Think they did not work hard enough if they do not do well in maths* and *Worry if they do not do well in maths)* regarding girls' self-doubt and worry about ability are not considered positive or negative. It is curious that although parents see girls as hard workers with high expectations, they also believe they are more likely to suffer self-doubt and worry about their mathematical ability.

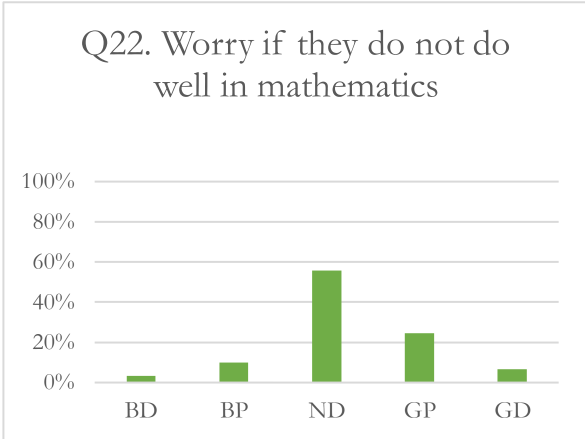
Figure 4.3

Statements where parents' mean response tended towards girls and related to their self-concept in mathematics.

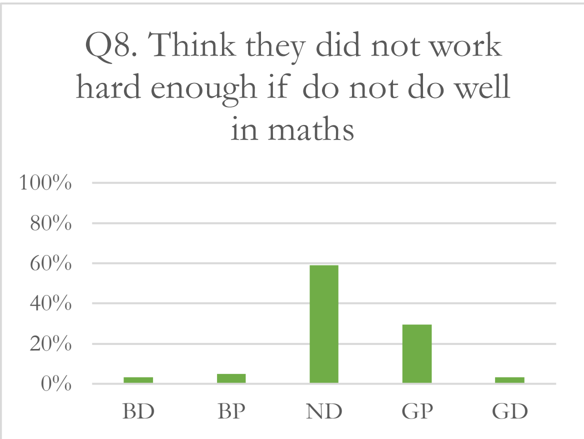
A



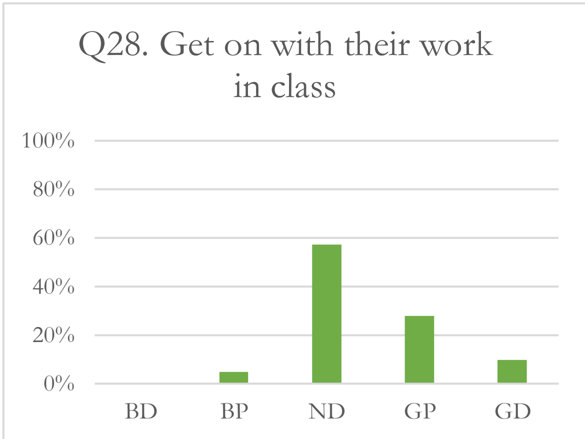
B



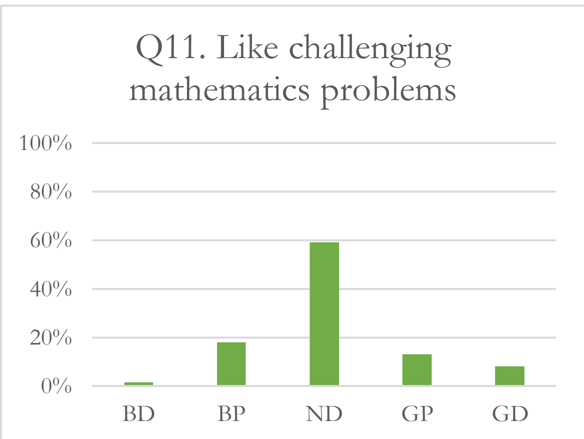
C



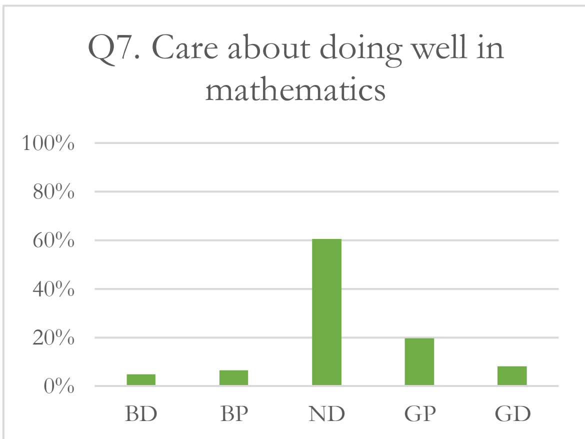
D



E



F



Note. BD = boys definitely, BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

Parents associated five out of the eleven statements to do with self-concept to the boys. However, the overall view is not as positive as that associated with the girls. Parents' views regarding the boys' relationship with mathematics show that they think boys have a poor attitude in class, with four out of the five statements considered negative. The most sizeable response in the parent survey was for the statement that boys are more likely to *distract other students from their work* (Figure 4.4A). Parents' responses showed that 42% considered boys would probably or definitely distract others in class while only 5% thought that girls might be distracting their classmates. Similarly, parents think boys are more likely to disturb their classmates, with 25% of parents thinking that boys would be likely to tease other boys and girls at an equal rate (Figures 4.4B & C). This is compared to girls whom parents think will tease boys (12%) and other girls (8%).

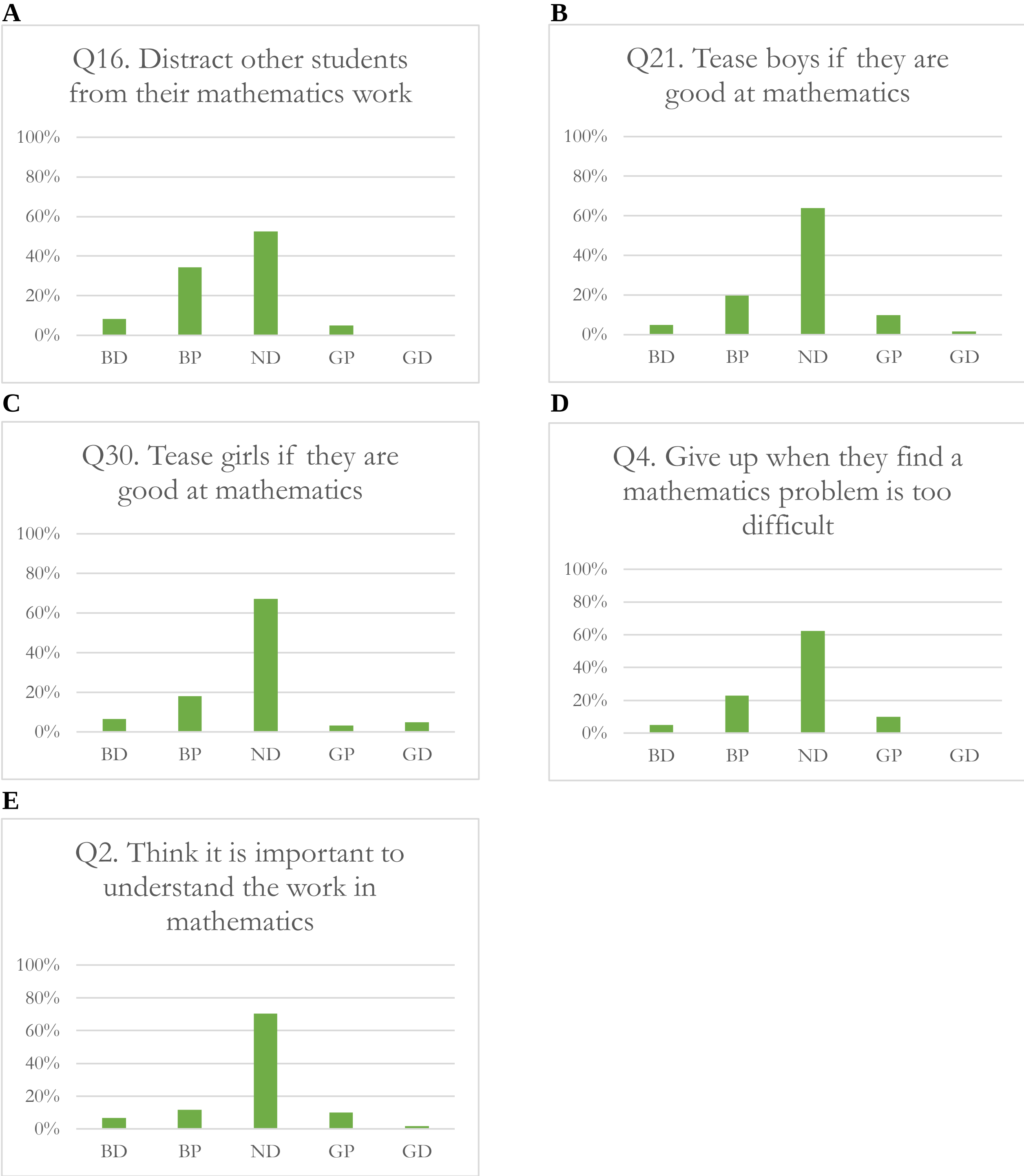
The view of who would *give up when they find a mathematics problem is too difficult* (Figure 4.4D) was viewed as a characteristic more likely to be associated with boys (28%) compared to girls (10%). Parents also believe that boys *think it is important to understand the work in mathematics* (18%) compared to girls (12%) (Figure 4.4E). One of the participants, Father C discussed the self-concept of boys in school in the interview when he stated:

> I just want him to enjoy going to school, I just want him to do well and the way he started, I just want him to keep going but I know how things are for young boys and I know that things can get side-tracked. So, I just want him to keep doing what he's doing and be keen and to work hard and just the usual things as a parent.

The overall data on girls' and boys' self-concept and mathematics gives the impression that parents believe girls are more likely to apply themselves in mathematics than boys. During the follow-up interview, Father B reflected on the girls' work ethic and said "I think girls enjoy doing well in things, they enjoy patterns, and I believe that they take a lot of pride in what they do. I think in a general way that applies to maths for girls."

Figure 4.4

Statements where parents' mean response tended towards boys and related to their self-concept in mathematics.



Note. BD = boys definitely, BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

4.2.2.3.2 Parents' Perceptions of Gender and Aptitude in Mathematics

Of the six statements related to aptitude in mathematics, four were related to girls, one was related to boys and one statement was not associated with either gender (Table 4.6)

Table 4.6

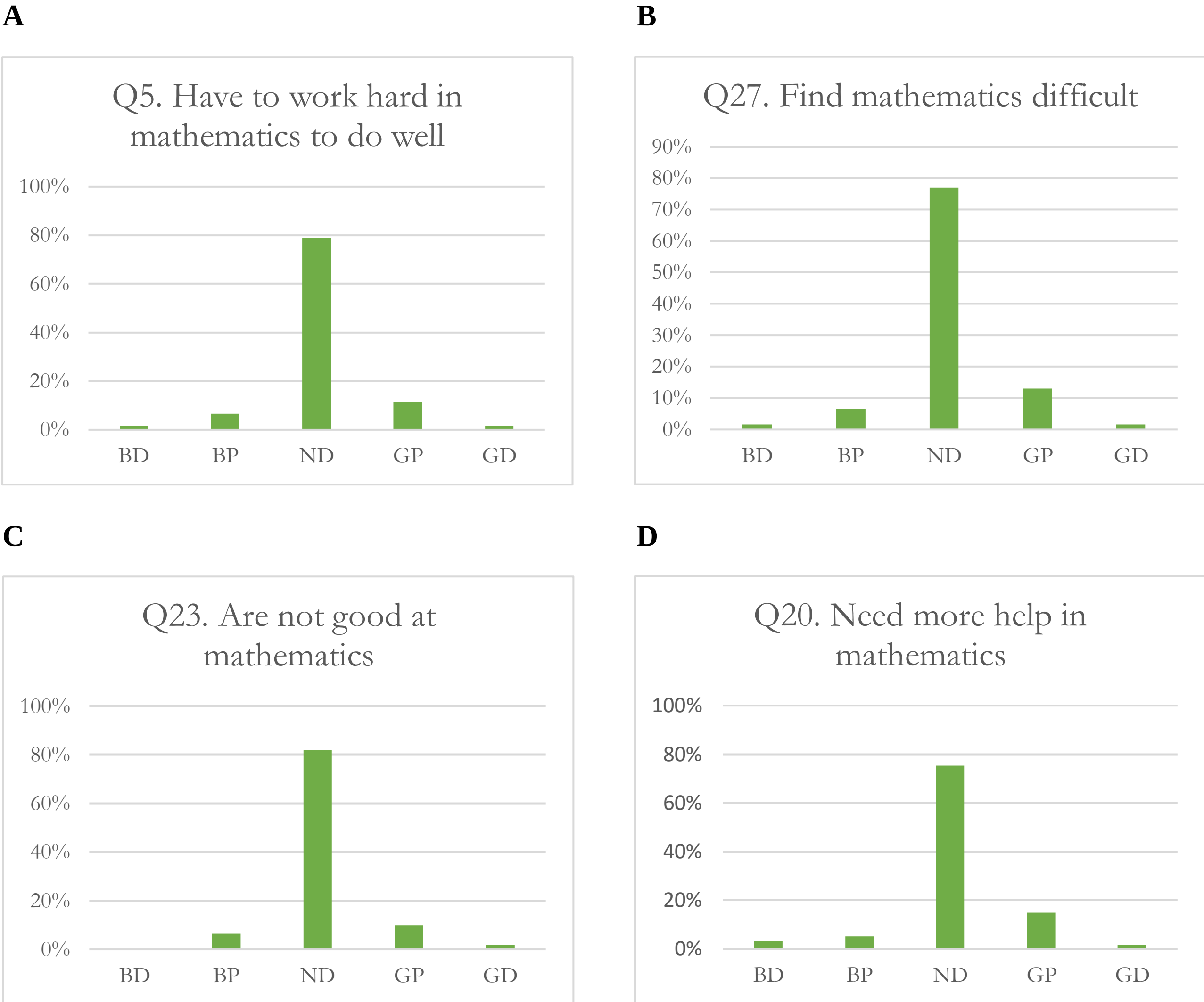
Parents' perception of gender and aptitude towards mathematics

	Statement	Parents' mean (n=61)	Values
Statements that parents attributed more to girls	Are not good at mathematics	.066	–
	Find mathematics difficult	.066	–
	Need more help in mathematics	.066	–
	Have to work hard in mathematics to do well	.049	–
Statements that parents attributed more to boys	Get the wrong answers in mathematics	–.049	–
Statements that parents considered no difference between girls and boys	Find mathematics easy	.000	+

Parents' perceptions of girls' mathematical aptitudes are not as positive as their views of girls' self-concepts. There were five statements relating to aptitude in the *Who and Mathematics* survey. Parents thought that four of these applied to girls and of these statements, all four were identified as being negative. Parents' mean results indicate that parents do not think girls have a natural aptitude for mathematics and believe they require more support, with the reverse being true for boys. The data shows that parents believed girls were more likely to *have to work hard in mathematics to do well*, with 13% of parents selecting this statement for girls compared to 9% choosing boys (Figure 4.5A). When asked to consider who would *find mathematics difficult*, 15% of parents considered that this would more likely apply to girls rather than boys (9%) (Figure 4.5B). In addition, parents are more likely to think that girls *are not good at mathematics*, with 12% of parents selecting girls as *not good at mathematics* compared to 7% for boys (Figure 4.5C). Given parents' perception that girls lack natural talent, it was unsurprising to see that parents considered girls to be more likely to *need more help in mathematics* (17%) compared to boys (8%) (Figure 4.5D).

Figure 4.5

Statements where parents' mean response tended towards girls and related to their aptitudes in mathematics.

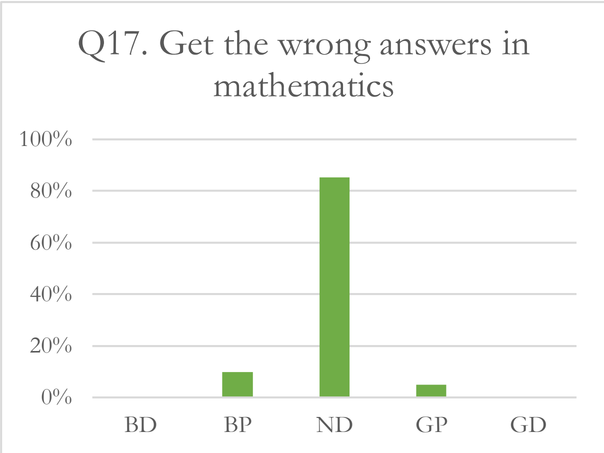


Note. BD = boys definitely, BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

When considering boys' mathematical aptitude, parents thought only one statement was more applicable to boys. More parents (10%) responded that boys would *get the answers wrong* compared to girls (5%) (Figure 4.6). This statement relating to aptitude can be considered negative. In light of the parents' views regarding girls' aptitude, this initially seems contradictory. However, it makes more sense if this is considered alongside parents' view of boys' poor attitude to mathematics and a perceived lack of effort in section 4.2.2.3.1.

Figure 4.6

Statements where parents' mean response tended towards boys and related to their aptitudes in mathematics.



Note. BD = boys definitely, BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

4.2.2.3.3 Parents' Perceptions of Gender and Encouragement from Role Models

Similar to previous results discussing engagement, there were no statements that parents felt related more to girls concerning mathematical role models and influence. The five statements were to do with the most likely role models for children at this age, their parents and teachers, and the way they may shape children's view of themselves as they engage in mathematics (Table 4.7).

Table 4.7

Parents' perception of gender and encouragement from role models

	Statement	Parents' mean (n=61)	Value
Statements that parents attributed more to boys	Are asked more questions by the mathematics teacher	-.213	+/–
	Parents think it is important for them to study mathematics	-.164	+
	Parents would be disappointed if they do not do well in maths	-.115	+
	Are encouraged to do well by the mathematics teacher	-.066	+/–
	Mathematics teachers spend more time with them	-.016	+/–
Statements that parents considered no difference between girls and boys	Mathematics teachers thinks they will do well	.000	+

Based on the mean responses, parents' views support the idea that significant role models provide the message that mathematics is more important for boys. When considering the role models that boys have and the mathematical messages they share, out of the five statements, two were positive, and three were considered neutral. Interestingly, there were no instances of the parents' mean skewing towards girls regarding mathematical role models.

Parents view mathematics as more important for boys to study (Figure 4.7A). In the statement *parents think it is important for them to study mathematics*, parents stated this would apply to boys (16%) more than girls (2%). For this statement, only one parent thought it would be more important for girls to study mathematics. When considering the statement *parents would be disappointed if they did not do well in mathematics* (Figure 4.7B), 13% of parents thought this applied to boys rather than 5% to girls.

During the interviews, many parents self-identified as poor mathematics students themselves but felt that it was important that their children be successful in mathematics. During the interview, parents were asked to role-play a scenario where they responded to their child who was finding mathematics demanding:

Mother A acknowledges her dislike of mathematics in the following scenario while also stating its importance and encouraging her son to persevere when she says:

I would ... it depends. I think maths is really important. And I would probably put my, I would say to him, well, mummy doesn't like maths. But it is sometimes, maths is things that you need to do. I would probably try to encourage him.

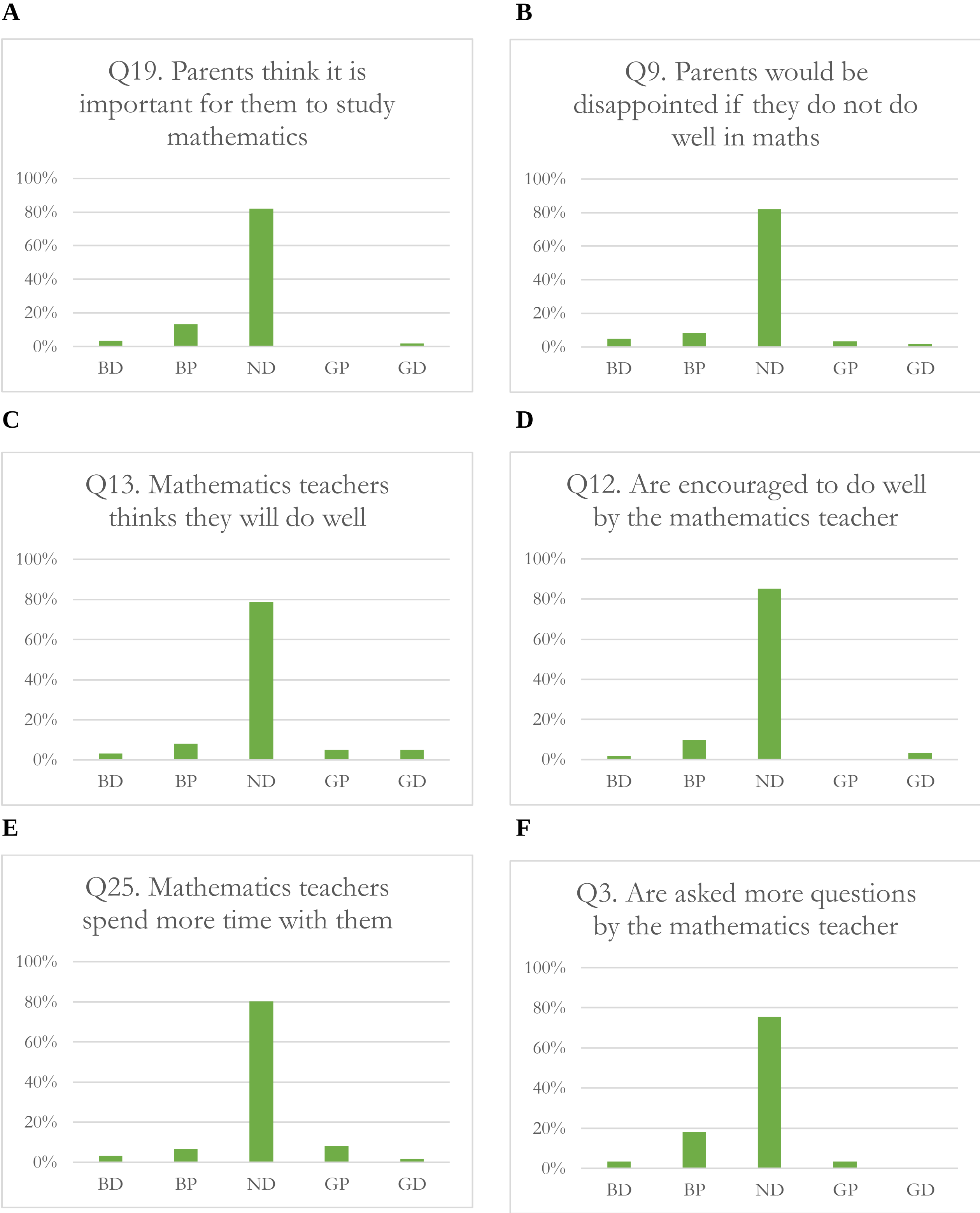
Remarkably, although Mother B was interviewed about her Kindergarten son she chose to role-play this scenario with her Year 4 daughter in mind instead:

(Daughter), I want you to do maths. I would get you a tutor if you have to. I can't say I can help you, because I'm not good, but yeah. Because she needs, you need it in life. And you want to be a teacher, so ...

Parents do not believe that teachers have a fixed idea of one gender being more successful in mathematics. When asked about the statement *mathematics teachers think they will do well*, parents' responses marginally applied more so to boys (11%) than girls (10%) (Figure 4.7C). They believe that boys are more likely to be *encouraged to do well by the mathematics teacher* (Figure 4.7D) (12%) compared to girls (3%). When parents considered whether *mathematics teachers spend more time with them*, there was an equal split for boys (10%) and girls (10%) (Figure 4.7E). When it comes to who is being *asked more questions by the mathematics teacher* (Figure 4.7F), parents think that this applies to boys (21%) more than girls (3%).

Figure 4.7

Parents' perceptions of encouragement from role models on boys and girls.



Note. BD = boys definitely. BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

4.2.2.3.4 Parents' Perceptions of Gender and Engagement in Mathematics

In contrast to the themes of self-concept and aptitude, parents' mean response relating to engagement skewed towards boys for all of the statements. There were five statements regarding engagement in total (Table 4.8)

Table 4.8

Parents' perception of gender and enjoyment in mathematics

	Statement	Parents' mean (n=61)	Value
Statements that parents attributed more to boys	Mathematics is their favourite subject	-.311	+
	Think mathematics is interesting	-.131	+
	Enjoy mathematics	-.131	+
	Like using computers to work on mathematics problems	-.098	+/–
	Consider mathematics to be boring	-.033	–

Overall, parents see mathematics as more likely to engage boys' interest, even though in the previous sections, parents' responses showed they believed boys would be less likely to engage with mathematics as diligently as girls. Parents thought that all five statements regarding engagement related to the boys and this was mixed in terms of the values assigned. Three of the statements were positive regarding the interest and enjoyment of mathematics, one was neutral, related to the boys' interest in using computers in mathematics, and the final statement was negative, and also at odds with the others, that boys are more likely to find mathematics boring. When considering who would *think mathematics is interesting*, 25% of parents believe that boys would probably or definitely consider this to be the case (Figure 4.8A). Parents' views on who is interested and who would say *mathematics is their favourite subject* received similar responses, with 28% of parents believing that boys would choose mathematics as their favourite subject. Curiously, responses for the statement *consider mathematics to be boring* showed that 15% of parents selected 'girls probably' compared to 8% for 'boys probably'. However, an additional 5% of parents selected 'boys definitely' (Figure 4.8B). This is an unexpected response because parents also believe that boys are more likely to find mathematics interesting (Figure 4.8A). Furthermore, parents stated that boys *enjoy mathematics* more than girls, with

29% thinking boys *enjoy mathematics* compared to 16% thinking girls would *enjoy mathematics* (Figure 4.8C). Parents also believe boys are more likely to *like using computers to solve mathematics problems*, with 18% of parents selecting boys compared to 8% of parents selecting girls (Figure 4.8D).

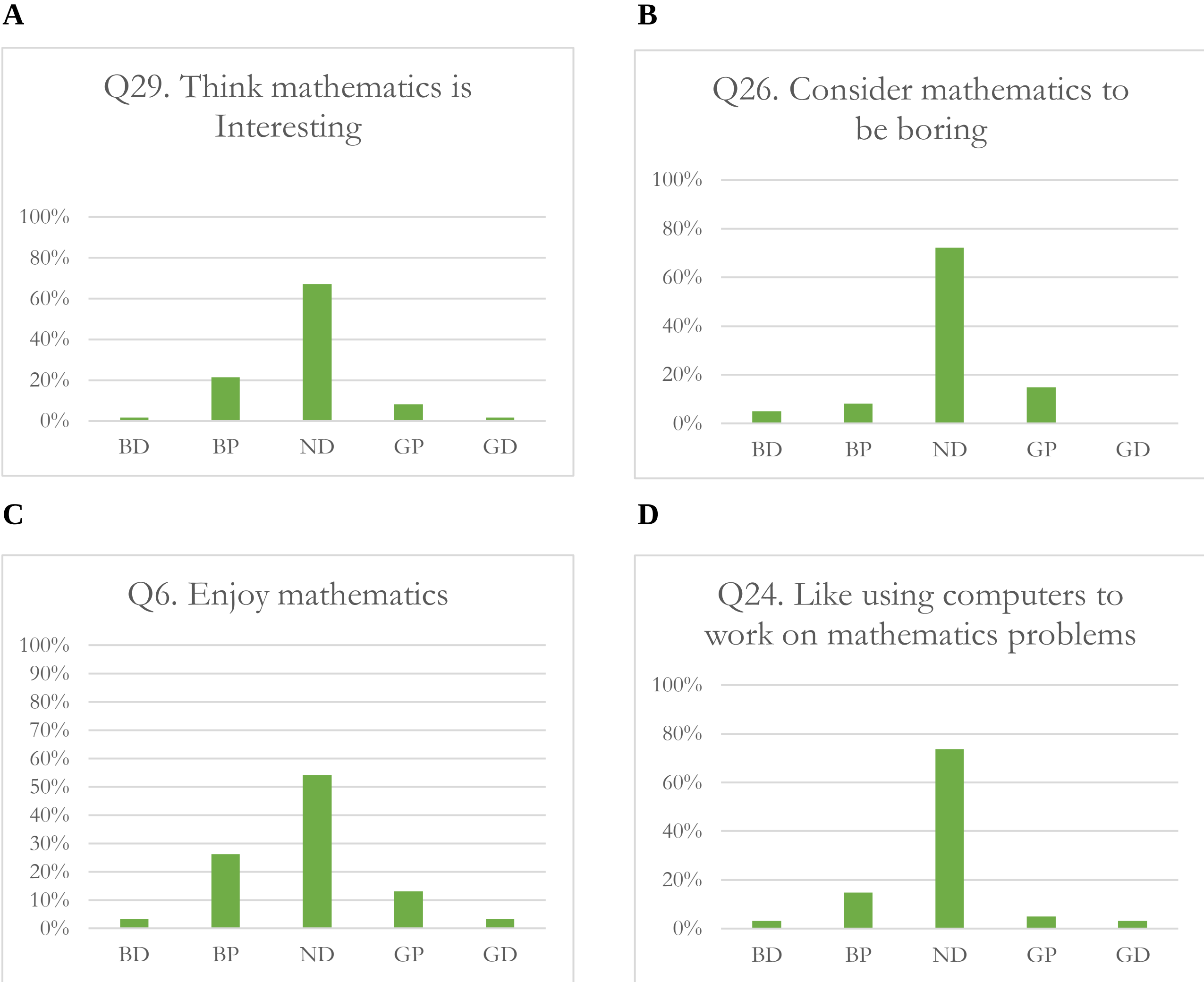
When probed about this during the interview, parents clarified that their opinions were based on their own past mathematical experiences, their child's experiences and other parents' viewpoints. One of the participants, Father C commented during the interview:

> I think that from talking to a lot of other dads that I know their sons are keen on maths and my son is definitely keen on maths and I was as well so that's probably why, yeah, I just think that boys need to be, I think they need to be stimulated a bit more. I think Maths is a bit more exciting than English and other stuff.

Mother A concurred with this sentiment when she said "He finds it very interesting. But girls can too, but for me, I think I've seen, a lot of boys find it even more interesting. It's like a competitive thing."

Figure 4.8

Parents' perceptions of boys' and girls' engagement in mathematics.



Note. BD = boys definitely. BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

Parents believe boys are more likely to be interested in and enjoy mathematics, consider it their favourite subject and like using computers to solve mathematics problems compared to girls. To further demonstrate these gendered views, there was no mean response relating to interest in mathematics that parents felt applied to girls. Understanding parents' responses in the statements relating to the messages both girls and boys receive from significant role models can help to understand these perspectives more clearly.

4.2.2.3.5 Parents' Perceptions of Gender and the Relevance of Mathematics in Later Life

There were two statements relating to the relevance of mathematics in later life (Table 4.9)

Table 4.9

Parents' perception of gender and relevance of mathematics in later life

	Statement	Parents' mean (n=61)	Value
Statements that parents attributed more to boys	Think mathematics will be important in their adult life	-.262	+
	Need maths to maximise future employment opportunities	-.164	+

Overall, parents consider mathematics to be less important for girls as they grow older. This is demonstrated by parents selecting statements regarding the relevance of mathematics in adult life as only relating to boys. Of the two statements relating to the importance of mathematics in later life, both were assigned to boys, and both were considered to be positive. This view became a commonly discussed theme in the follow-up interviews with many parents considering mathematics to be more relevant for boys and the types of careers they felt they were likely to undertake. Father B stated:

> Look, I believe ... I'm an older parent but I believe that a lot of parents still will push their boys into doing maths to get further ahead post school. They don't then push girls to do maths just for the same chance. I don't think it'll be the same push to get women to have those opportunities.

When asked to consider the statement *think mathematics will be important in their adult life*, parents thought this related to boys (28%) more so than girls (5%) (Figure 4.9A). When considering future employment with the statement *needs mathematics to maximise future learning opportunities*, only 5% of parents stated that mathematics would be more important for girls (Figure 4.9B). Comparatively, 23% of parents responded that boys needed mathematics to maximise employment opportunities.

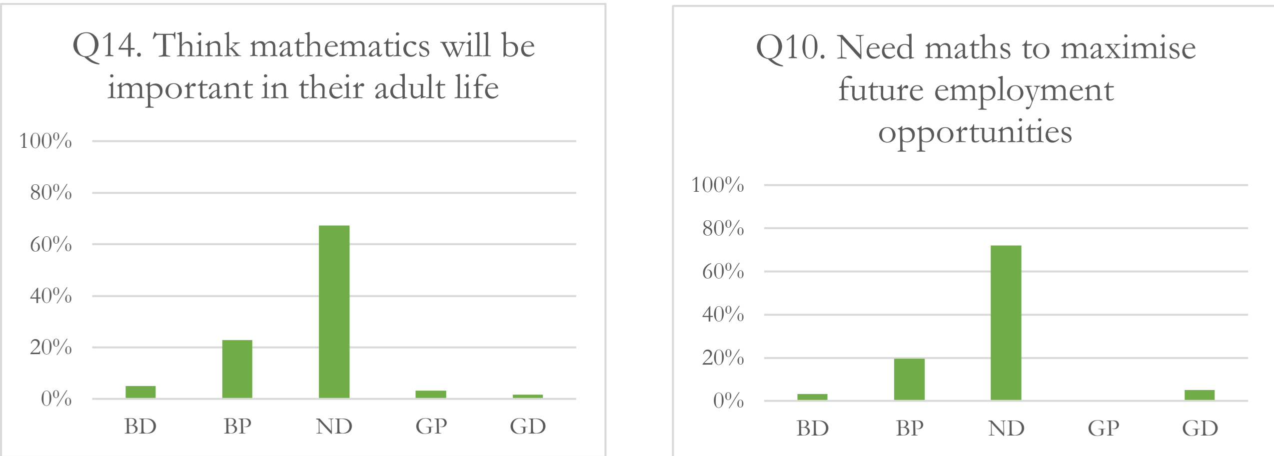
During the interview, Mother D explained in more detail why she thought mathematics was more important for boys in later life:

> Maths for boys I found is more important for completing school. If they didn't want to go in an office. I think if girls had to fall back onto a career or what not, they could always fall back into an office, and you've got calculators and that thing, being more literacy types they would need (them). Whereas boys would be in an apprenticeship, building, that sort of hands-on skills where they would need to rely a bit more on maths.

Figure 4.9

Parents' perceptions of the relevance of mathematics to girls and boys in later life.

A **B**



Note. BD = boys definitely. BP = boys probably, ND = no difference, GP = girls probably, GD = girls definitely.

4.3 Summary

The focus of this chapter has been to present the findings in relation to the views of parents regarding girls' and boys' mathematical identities. Parents demonstrated some stereotypical thinking regarding mathematics as a male domain. While most parents responded to statements with 'no difference', when they considered there was a difference, they attributed positive associations with girls' behaviour and work ethic and did not believe they have the equivalent mathematical aptitude. Parents who had a view other than 'no difference' also believed that girls are more anxious about their ability in mathematics. These parents viewed girls as harder workers than boys as a necessity due to their inherent lack of aptitude. They also thought girls had higher expectations of achievement and would worry more about their lack of effort if they received poor results. Parents who perceived a difference between the genders thought girls would persevere with mathematics despite their perceived lack of interest in the subject or a sense of the value of its importance.

When parents considered boys' characteristics, those that consider there is a difference thought they were more inherently capable and interested in mathematics, although lacking the application that girls possess. These parents believed mathematics would be utilised more by boys as they move into adulthood and look for employment. The parents interviewed discussed a sense of 'male' and 'female' vocations. Chapter Five presents the responses from the children and compares and contrasts child responses to parent responses for similarities.

Chapter Five: Presentation of Research Findings from Children

5.1 Overview

The focus of this chapter is to present responses relating to the research sub-questions:

- *How are boys and girls describing their mathematical capabilities and relationship with mathematics at the beginning and end of their first year of school?*
- *What is the relationship between the views that parents and children hold regarding gender and identity?*

A modified and child-friendly version of the *Who and Mathematics* Survey was administered to Kindergarten students to answer these questions. To ensure that all Kindergarten students understood the questions and were able to give a clear response, an interview format was used with the students as they would need well-developed literacy skills to complete the survey independently. The interview was conducted twice, at the beginning of Term 1 and the end of Term 4, to see if perspectives had changed across the year.

This chapter is organised into two sections. Section One analyses the children's responses to the modified *Who and Mathematics* survey in Term 1 and Term 4, noting where the mean tends towards boys or girls. In addition, this analysis will see if changes in children's views have occurred between the beginning and the end of the year. This will be organised by theme and value similarly to the parent analysis in Chapter Four. Section Two will then compare the parents' and children's views to see if there are correlations. Finally, the chapter will conclude with a summary of the findings.

Table 5.1

Overview of Chapter Five: Presentation of Research Findings from Children

5.1	**Overview**
5.2	**Children's Perspectives on Gender and Mathematics**
5.3	**Comparison of Parents' and Children's Views in Each Theme**
5.4	**Summary**

5.2 Children's Perspectives on Gender and Mathematics

For this section of the study, children in Kindergarten participated in one-on-one interviews to complete the modified *Who and Mathematics* survey, comprising 39 boys and 39 girls in Term 1 (beginning of the school year) and 35 boys and 37 girls in Term 4 (end of the school year). Across almost all questions, boys and girls had statistically significantly different responses.

In order to quantify this data, responses in the survey (boys, girls or no difference) were assigned a numerical value from -1 to +1. The response for 'boys' was assigned -1, 'no difference' with 0 and 'girls' with +1. When the mean results were analysed, it became clear that boys and girls have very different viewpoints regarding mathematical attributes. In Term 1, 16 out of the 20 statements were significantly different between girls' and boys' responses to the survey (Table 5.2). The four statements that did not show a statistically significant difference between girls and boys in Term 1 were:

- Statement 3: Which one will have to work hard at counting and numbers to get it right?
- Statement 7: Which one needs maths when they grow up and get a job?
- Statement 9: Which one thinks maths will be important when they're grown-ups
- Statement 13: Which one do you think will need more help in maths?

However, it is important to note that although these statements were not statistically significantly different, boys' and girls' mean responses were still tending towards opposing genders. Their responses were simply less pronounced than the responses to the other 16 statements (Table 5.2).

Table 5.2

Term 1 Comparison of girls' and boys' responses to the Who and Mathematics survey

Statement	Girls' mean (n=39)	Girls' SD (n=39)	Boys' mean (n=39)	Boys' SD (n=39)	P-value	Significance
1	.128	.656	-.333	.577	.001	**
2	-.282	.793	.410	.818	.000	***
3	.103	.718	-.179	.823	.111	
4	.256	.751	-.359	.628	.000	***
5	.205	.695	-.333	.737	.001	**
6	-.333	.621	.154	.745	.002	**
7	.051	.560	-.077	.703	.376	
8	.000	.649	-.359	.778	.030	*
9	.179	.721	-.128	.695	.059	
10	.308	.614	-.333	.701	.000	***
11	-.487	.644	.436	.718	.000	***
12	.256	.715	-.564	.641	.000	***
13	-.154	.709	.103	.718	.117	
14	-.333	.662	.385	.673	.000	***
15	-.410	.715	.487	.644	.000	***
16	.359	.668	-.205	.767	.001	**
17	-.513	.644	.308	.800	.000	***
18	-.308	.694	.462	.720	.000	***
19	.436	.718	-.487	.601	.000	***
20	-.487	.683	.385	.673	.000	***

*$p<.05$, **$p<.01$, ***$p<.001$. SD = standard deviation.

In Term 4, it appears boys' and girls' views are becoming more similar, reducing from 16 to 12 out of 20 statements being significantly different (Table 5.3). The eight statements that did not show a statistically significant difference between girls and boys in Term 4 were:

Same as Term 1:

- Statement 3: Which one will have to work hard at counting and numbers to get it right?
- Statement 7: Which one needs maths when they grow up and get a job?
- Statement 13: Which one do you think will need more help in maths?

Different to Term 1:

- Statement 2: Which one will give up when they find a counting problem that is too hard?
- Statement 5: Which one would care the most about doing well in maths?

- Statement 6: Which one's parents would be sad or disappointed if they didn't do well in maths?
- Statement 8: Which one likes it when maths and counting gets a little harder?
- Statement 18: Which one finds maths hard?

Similar to Term 1, statements 3, 7 and 13 were also not significantly different between girls and boys in Term 4. Of the eight statements that were not statistically significant, there was only one statement where boys and girls agreed on the gender most likely to have a particular capability. Both boys and girls nominated girls as *having to work hard at counting and numbers to get it right* (Statement 3). In both Term 1 and 4, girls have selected Statement 3 to be associated with girls. However, boys associated Statement 3 with boys in Term 1 but chose girls in Term 4. When children considered *who likes it when maths and counting gets a little harder* (Statement 8), girls thought there was *no difference* with boys selecting themselves. When responding to who is likely to *find maths hard* (Statement 18), girls considered there would be *no difference*, and boys thought it was more likely to be a characteristic of girls. For Statements 2, 5 and 6, girls and boys selected opposing genders; however, they were all close to *no difference* with a mean between -0.189 and 0.171 (Table 5.3).

Statement	Girls' mean (n=37)	Girls' SD (n=37)	Boys' mean (n=35)	Boys' SD (n=35)	P-value	Significance
1	.081	.862	-.371	.646	.014	*

2	-.081	.894	.029	.891	.604	
3	.189	.739	.143	.733	.790	
4	.216	.712	-.171	.664	.020	*
5	.189	.845	-.143	.772	.087	
6	-.189	.811	.171	.747	.054	
7	-.162	.688	-.086	.658	.632	
8	.000	.816	-.171	.822	.378	
9	.324	.626	-.171	.618	.001	**
10	.162	.727	-.200	.677	.032	*
11	-.081	.829	.286	.710	.048	*
12	.054	.880	-.400	.651	.016	*
13	-.054	.848	.229	.843	.161	
14	-.108	.809	.286	.710	.032	*
15	-.135	.787	.343	.639	.006	**
16	.351	.789	-.543	.505	.000	***
17	-.432	.801	.286	.750	.000	***
18	.000	.816	.314	.758	.095	
19	.351	.753	-.229	.731	.001	**
20	-.378	.721	.229	.731	.001	***

Table 5.3

Term 4 Comparison of girls' and boys' responses to the Who and Mathematics survey

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$. SD = standard deviation.

When the responses of the boys and girls in both Terms 1 and 4 were analysed, it became evident which statements had a mean response furthest from zero. This should indicate more agreement from children towards the statement being gendered, and the statements' mean responses can be ranked to show the strongest gendered responses and the most neutral gendered responses.

In Term 1, girls' strongest responses were to do with interest in mathematics (Figure 5.1). The statement that girls thought related most to themselves was *which one thinks maths is interesting* with a mean response of 0.436. Conversely, the girls thought the statement *which one thinks maths is boring* would be more likely to apply to the boys with a mean of -0.513. By Term 4, the ranking of the statements showed little change for girls (Figure 5.2). The highest mean response for girls is still *which one thinks maths is interesting* (0.351), although this statement now shares the highest mean score with the statement *which one likes using computers to do maths*. Girls still believe that boys are more likely to think *maths is boring*, with a mean score of -0.432. Although these two statements remain the responses that girls most consistently responded with, the mean score is lower for each in Term 4.

Figure 5.1

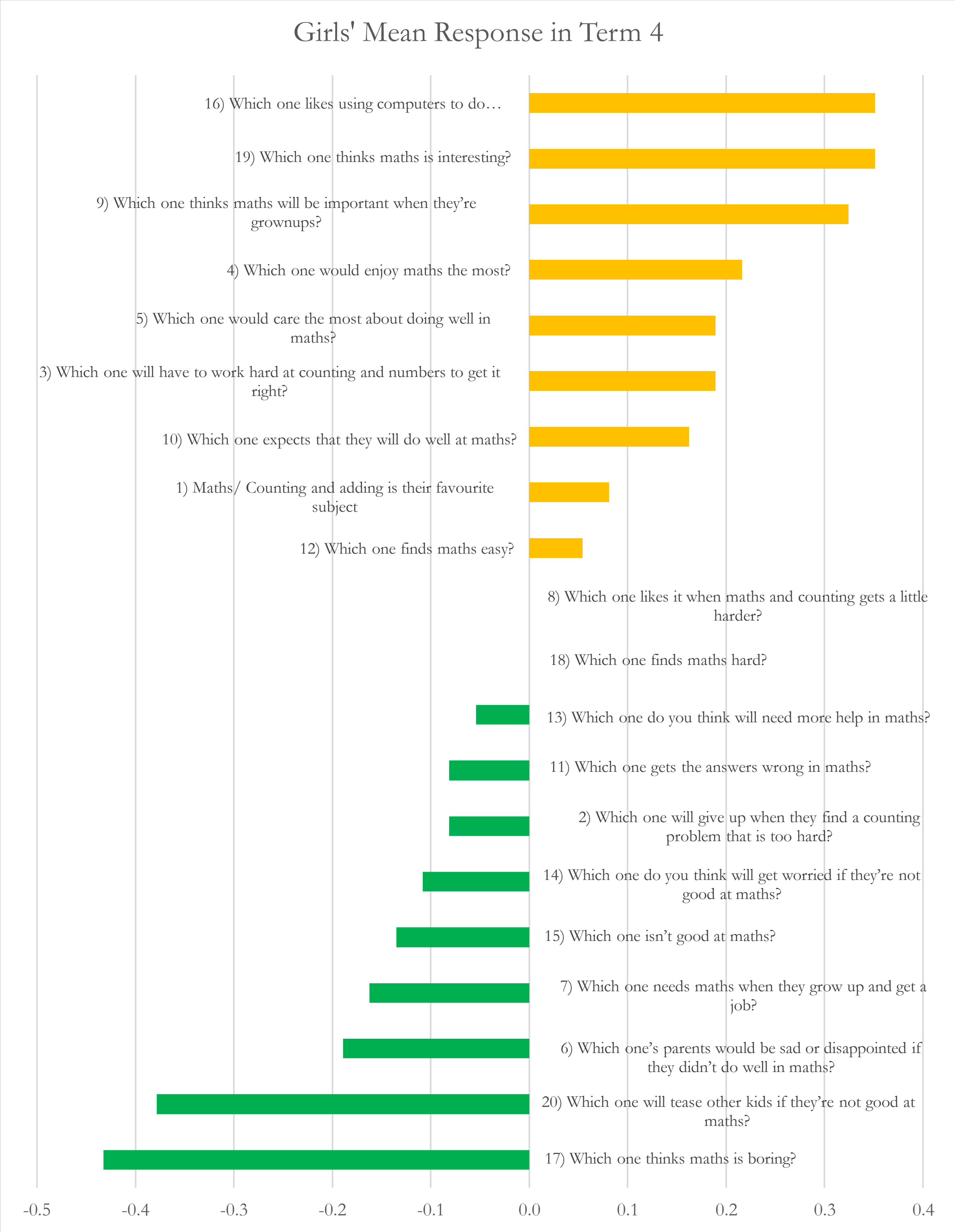
Girls' Term 1 mean response in the Who and Mathematics Survey

Note. Yellow bars represent girls' views towards girls, and green bars represent girls' views towards boys or clear for no difference.

Figure 5.2

Girls' Term 4 mean response in the Who and Mathematics Survey.

Note. Yellow bars represent girls' views towards girls, and green bars represent girls' views



towards boys or clear for no difference.

Analysis of the boys' mean responses shows that they have different perspectives compared to the girls. While the girls' highest-ranked responses are to do with interest, boys' responses are to do with aptitude. The highest mean response in Term 1 for boys was *which one finds maths easy* with a mean of -0.564 (Figure 5.3). This was the highest mean response in the survey for any response by both boys and girls. Conversely, boys thought that girls would be more likely to represent the statement *which one isn't good at maths* with a mean score of 0.487. In Term 4, boys' ranking of their top responses does not change (Figure 5.4). However, the mean response is lower for both items. When boys considered *which one finds maths easy* in Term 4, the mean score reduced from -0.564 to -0.400. While boys still thought that the girls were most likely *not to be good at maths,* the mean response lowered from 0.487 in Term 1 to 0.343 in Term 4.

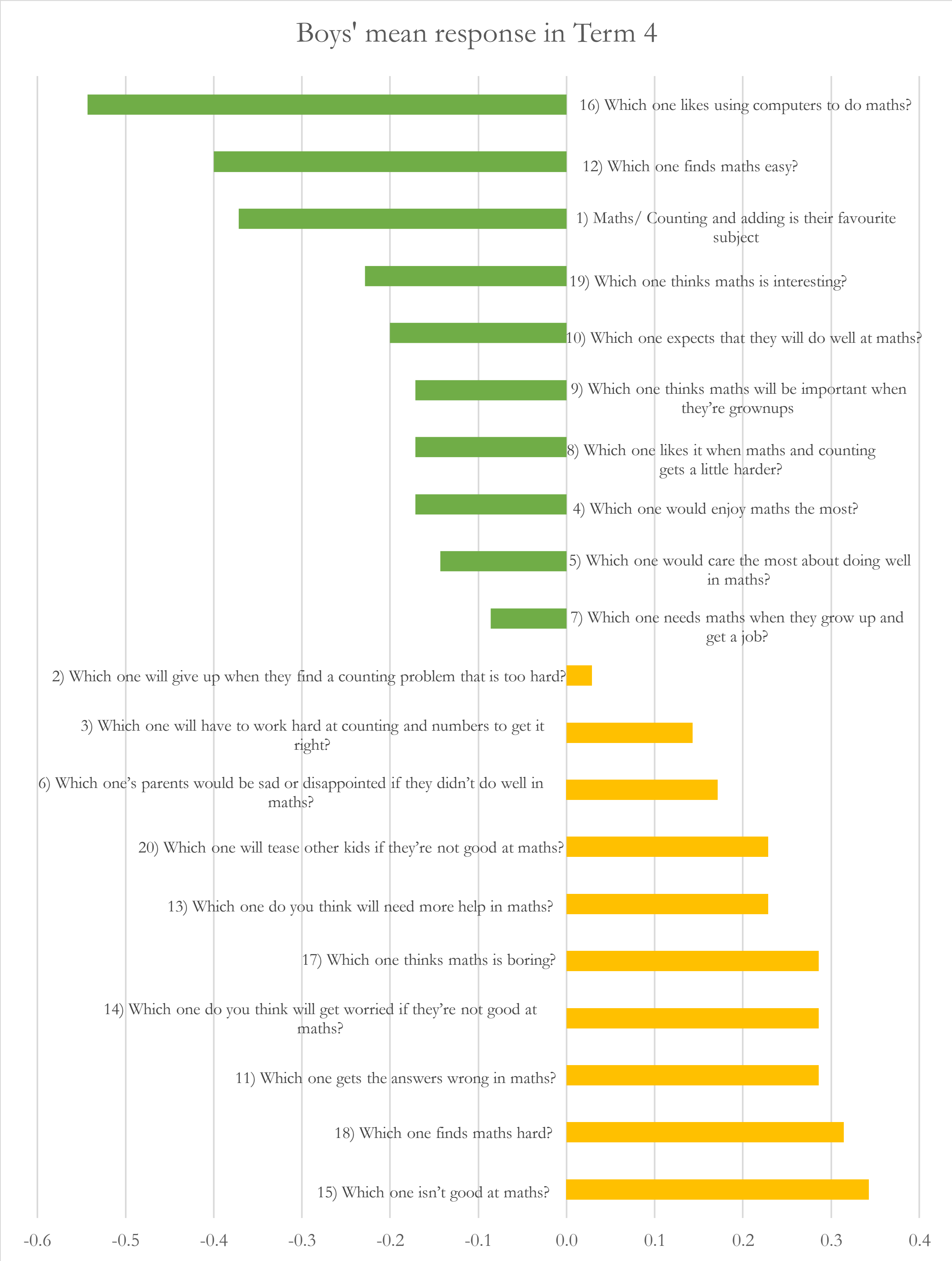
Figure 5.3

Boys' Term 1 mean response in the Who and Mathematics Survey.

Note. Green bars represent boys' views towards boys, and yellow bars represent boys' views towards girls or clear for no difference.

Figure 5.4

Boys' Term 4 mean response in the Who and Mathematics Survey.



Note. Green bars represent boys' views towards boys, and yellow bars represent boys' views towards girls or clear for no difference.

Overall, views became less gendered for both boys and girls as the school year progressed, and they were more likely to select *no difference* by Term 4. To better understand the motivation behind the boys' and girls' responses, statements from the *Who and Mathematics* survey were categorised into themes.

5.2.1 Categorisation of the *Who and Mathematics* Statements into Themes

Similar to Chapter Four, the children's statements have been categorised into themes. Specifically, themes previously assigned to the statements in the survey administered to parents were mapped to aligning statements in the children's survey (Table 5.4). Thus, the following themes were once again used to summarise the 20 statements.

- Self-concept (6 statements)
- Aptitude (6 statements)
- Encouragement from Role Models (1 statement)
- Enjoyment (5 statements)
- Relevance to later life (2 statements)

Table 5.4

Themes for the Modified Who and Mathematics Statements Administered to Kindergarten Children

Statement	Theme
1. Maths/ Counting and adding is their favourite thing to do	Enjoyment
2. Which one will give up when they find a counting problem that is too hard?	Self-concept
3. Which one will have to work hard at counting and numbers to get it right?	Aptitude
4. Which one would enjoy counting the most?	Enjoyment
5. Which one would care the most about doing well in maths/ counting?	Self-concept
6. Which one's parents would be sad or disappointed if they didn't do well in maths/counting?	Encouragement from Role Models
7. Which one needs maths/counting when they grow up and get a job?	Relevance to Later Life
8. Which one likes it when maths and counting gets a little harder?	Self-concept

9.	Which one thinks maths/counting will be important when they're grown-ups?	Relevance to Later Life
10.	Which one expects that they will do well at maths/ counting?	Self-concept
11.	Which one gets the answers wrong in maths/counting?	Aptitude
12.	Which one finds maths and counting easy?	Aptitude
13.	Which one do you think will need more help in maths/ counting?	Aptitude
14.	Which one do you think will get worried if they're not good at maths/ counting?	Self-concept
15.	Which one isn't good at maths/ counting?	Aptitude
16.	Which one likes using computers to do maths/ counting?	Enjoyment
17.	Which one thinks maths/ counting is boring?	Enjoyment
18.	Which one finds maths/ counting hard?	Aptitude
19.	Which one thinks maths/ counting is interesting?	Enjoyment
20.	Which one will tease other kids if they're not good at maths/ counting?	Self-concept

5.2.2 Positive and Negative Associations in the *Who and Mathematics* Survey

As in Chapter Four, the *Who and Mathematics* survey statements were assigned a positive, negative or neutral value. Again, this was defined by the students' relationship to mathematics. The only statement that was not clearly definable was *Which one likes using computers to do maths/counting?* This statement was considered an interest that is not necessarily related to the students' relationship with mathematics but is more to do with their interest in using computers. The table below summarises the twenty statements and their value (Table 5.5).

Table 5.5

Children's response options in the Who and Mathematics statements and their assigned values

Statement	Value
1. Maths/ Counting and adding is their favourite thing to do	+
2. Which one will give up when they find a counting problem that is too hard?	–
3. Which one will have to work hard at counting and numbers to get it right?	–
4. Which one would enjoy counting the most?	+
5. Which one would care the most about doing well in maths/ counting?	+
6. Which one's parents would be sad or disappointed if they didn't do well in maths/ counting?	+
7. Which one needs maths/ counting when they grow up and get a job?	+
8. Which one likes it when maths and counting gets a little harder?	+
9. Which one thinks maths/ counting will be important when they're grown-ups?	+
10. Which one expects that they will do well at maths/ counting?	+
11. Which one gets the answers wrong in maths/ counting?	–
12. Which one finds maths and counting easy?	+
13. Which one do you think will need more help in maths/ counting?	–
14. Which one do you think will get worried if they're not good at maths/ counting?	–
15. Which one isn't good at maths/ counting?	–
16. Which one likes using computers to do maths/ counting?	+/ –
17. Which one thinks maths/ counting is boring?	–
18. Which one finds maths/ counting hard?	–
19. Which one thinks maths/ counting is interesting?	+
20. Which one will tease other kids if they're not good at maths/ counting?	–

5.2.3 Children's Responses to the *Who and Mathematics* Survey Categorised into Gendered Themes

The five themes assigned to each of the statements in the *Who and Mathematics* survey will again be utilised, this time to explore children's responses. In addition to categorising the children's responses by theme, the data will be viewed by the child's mean response. The narrative that girls and boys perceive about themselves and the opposite gender can then be further understood. Term 1 and Term 4 data were analysed and compared using content analysis to see if views changed across the school year.

5.2.3.1 Children's Perceptions of Gender and Self-Concept in Mathematics in Term 1 and Term 4

There were six statements relating to self-concept in mathematics (Table 5.6). Girls' mean responses in Term 1 show that they *expect to do well at maths* (0.316) and *care about doing well at maths* (0.216). Girls' strongest response in Term 1 in the theme of self-concept was to the statement, *which one will tease other kids if they're not good at maths?* They thought this was more likely to apply to the boys with a mean response of –0.500. They also thought the statements, *which one do you think will get worried if they're not good at maths* and *which one will give up when they find a counting problem that is too hard*, would relate to boys with mean scores of –0.351 and –0.324, respectively. Girls responded neutrally in Term 1 to the statement *which one likes it when maths and counting get a little harder.*

Table 5.6

Girls' perceptions of gender and self-concept towards mathematics in Term 1

Girls' responses on self-concept in Term 1	Statement	Girls' mean (n=39)	Value
Statements that girls attributed more to girls in Term 1	Which one expects that they will do well at maths?	.316	+
	Which one would care the most about doing well in maths?	.216	+
Statements that girls attributed more to boys in Term 1	Which one will tease other kids if they're not good at maths?	−.500	−
	Which one do you think will get worried if they're not good at maths?	−.351	−
	Which one will give up when they find a counting problem that is too hard?	−.324	−
Statements that girls are neutral on in Term 1	Which one likes it when maths and counting gets a little harder?	.000	+

By Term 4, the statements that girls selected for themselves and boys did not change (Table 5.7). However, the mean response had decreased for all statements as girls tended to become more neutral in their opinions by the end of the school year. With regard to the value associated to each of the statements, girls selected two out of three positive statements as applicable to themselves, with the third positive statement being neutral and all negative statements associated with the boys.

Table 5.7

Girls' perceptions of gender and self-concept towards mathematics in Term 4

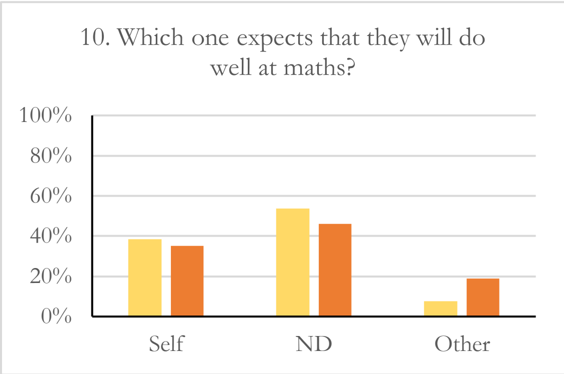
Girls' responses on self-concept in Term 4	Statement	Girls' mean (n=37)	Value
Statements that girls attributed more to girls in Term 4	Which one would care the most about doing well in maths?	.189	+
	Which one expects that they will do well at maths?	.162	+
Statements that girls attributed more to boys in Term 4	Which one will tease other kids if they're not good at maths?	-.389	–
	Which one do you think will get worried if they're not good at maths?	-.114	–
	Which one will give up when they find a counting problem that is too hard?	-.081	–
Statements that girls are neutral on in Term 4	Which one likes it when maths and counting gets a little harder?	.000	+

The girls' responses were also reviewed by looking at whether they chose *themselves*, *other* or *no difference* in Terms 1 and 4. In Term 1, 38% of girls attributed the statements *which one expects that they will do well at maths* to themselves (Figure 5.5A). A similar pattern was observed in Term 4, although girls were twice as likely to select the other gender (8% to 19%). A similar number of girls (36%) nominated themselves as more likely to *care the most about doing well in maths* (Figure 5.5B). This increased to 46% by Term 4 as girls also increased their view that boys would be more likely to care the most about doing well at maths (15% to 27%) and decreased their view that there was *no difference* (49% to 27%). The majority of girls selected *no difference* (59%) in Term 1 to the statement *which one likes it when maths and counting gets a little harder* (Figure 5.5C) and thought this statement was equally likely to apply to themselves (21%) or the boys (21%). By Term 4, although the mean response was still considered neutral, girls have decreased their response to there being *no difference* (35%) and selected gendered options, although at an equal rate (32% for both *self* and *other*). Girls thought that the boys were more likely to be represented by the statements *which one will tease other kids if they're not good at maths* with a response of 59% in Term 1, which decreased in Term 4 to 51% (Figure 5.5D). In response to the statement, *which one do you think will get* *worried if they're not good at maths*, 46% of girls felt that there was *no difference* (Figure 5.5E). This decreased in Term 4 to 35%, instead girls began to select this statement more for themselves at almost triple the amount (10% to 27%). In Term 1, girls thought it would be boys (49%) that would *give up when they find a counting problem that is too hard* (Figure 5.5F). This did not change much by Term 4 (49% to 43%) but girls did begin to increase their view that this would relate to themselves more (21% to 35%).

Figure 5.5

Girls' responses to statements relating to self-concept and mathematics in Term 1 and 4.

A



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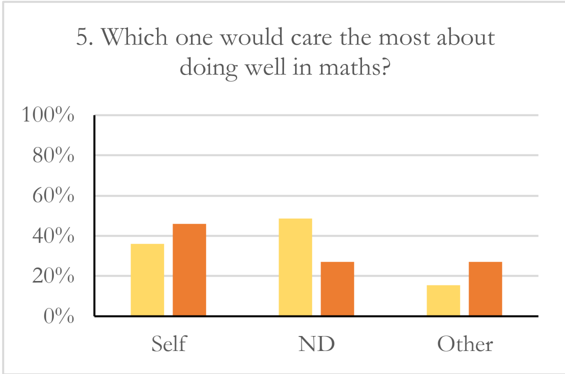

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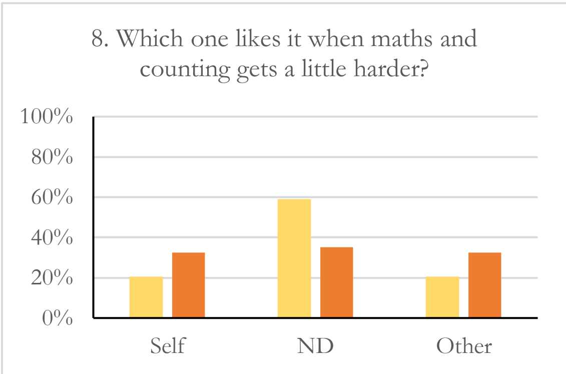

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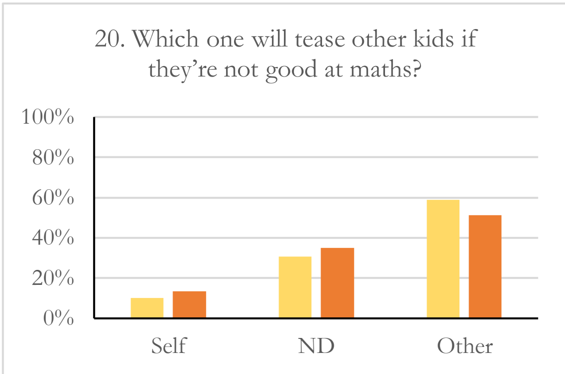

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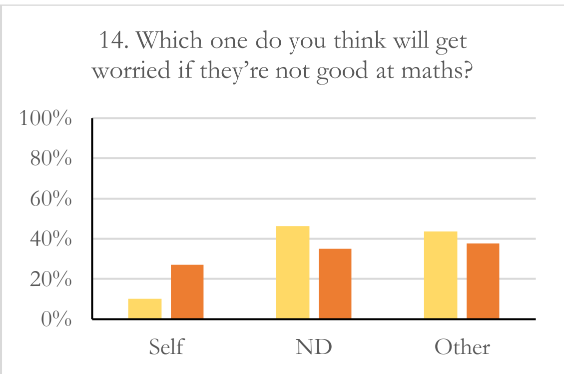
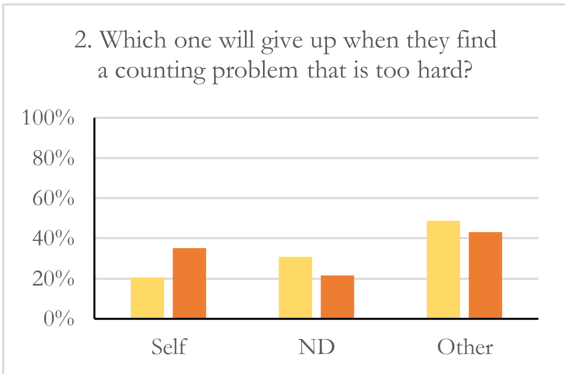


F



Note. Yellow bars represent Term 1 responses. Orange bars represent Term 4 responses. ND = no difference.

Overall, boys' perspectives were very similar to the girls'. They nominated themselves for all the positive statements in Term 1 (Table 5.8): *which one likes it when maths and counting gets a little harder* (-0.368), *which one would care the most about doing well in maths* (-0.361) and *which one expects that they will do well at maths* (-0.342). In comparison to the girls' responses, boys have a stronger mean response to each of these statements, particularly the statement about liking when maths becomes more challenging. The one exception is the statement about *teasing other kids if they're not good at maths*. Girls thought this related to the boys with a mean response of -0.500 compared to boys thinking it related to girls (0.395).

Table 5.8

Boys' perceptions of gender and self-concept towards mathematics in Term 1

Boys' responses on self-concept in Term 1	Statement	Boys' mean (n=39)	Value
Statements that boys attributed more to girls in Term 1	Which one will give up when they find a counting problem that is too hard?	.410	–
	Which one do you think will get worried if they're not good at maths?	.405	–
	Which one will tease other kids if they're not good at maths?	.395	–
Statements that boys attributed more to boys in Term 1	Which one likes it when maths and counting gets a little harder?	-.368	+
	Which one would care the most about doing well in maths?	-.361	+
	Which one expects that they will do well at maths?	-.342	+

By Term 4, boys still held the same beliefs. However, similar to the trend seen with the girls, the mean response had decreased for all statements as boys' views became more neutral (Table 5.9). Interestingly, when the change in boys' mean responses from Term 1 to Term 4 was compared to the girls' mean responses, it appears that boys are changing their minds more than girls.

Table 5.9

Boys' perceptions of gender and self-concept towards mathematics in Term 4

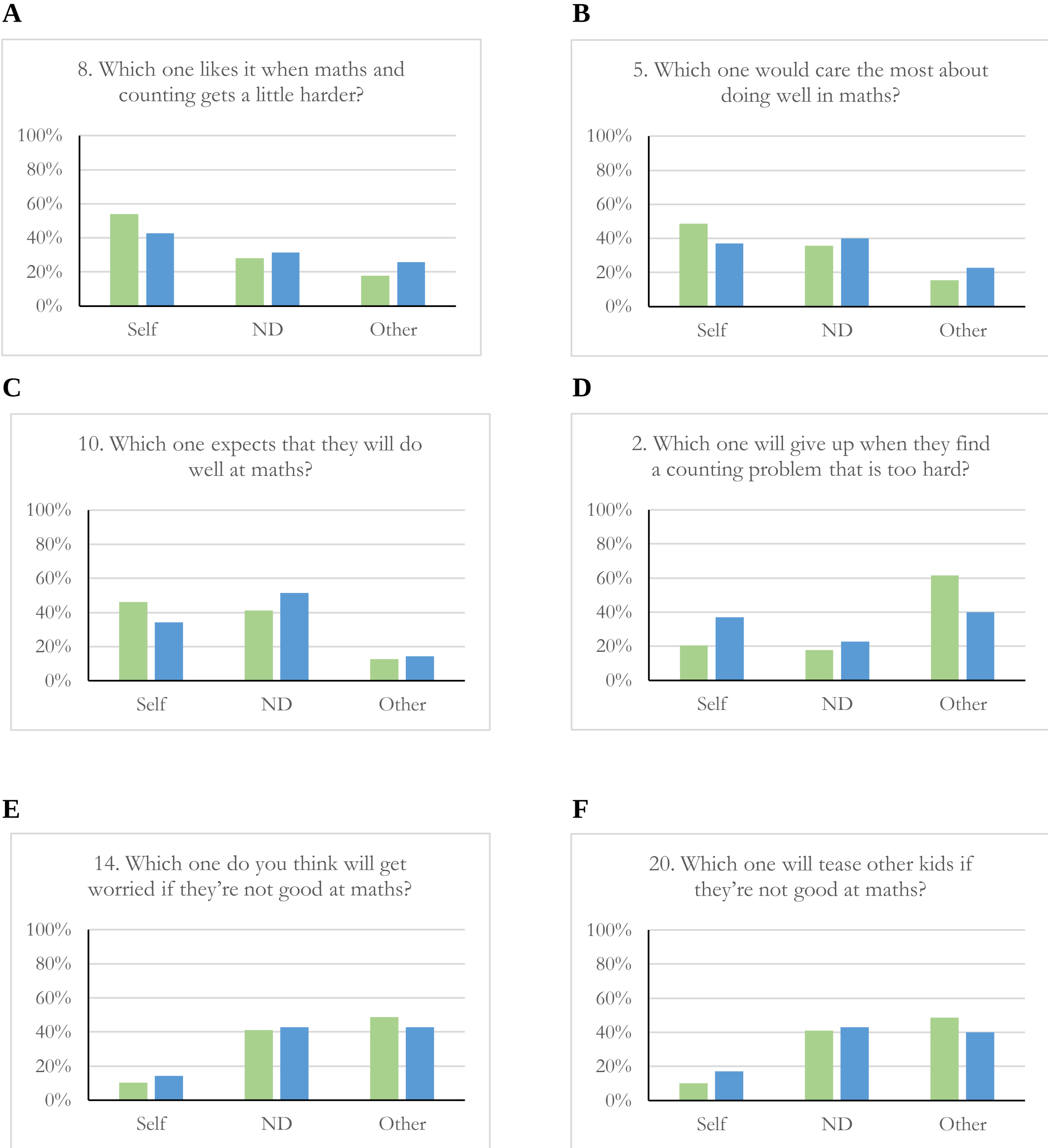
Boys' responses on self-concept in Term 4	Statement	Boys' mean (n=35)	Value
Statements that boys attributed more to girls in Term 4	Which one do you think will get worried if they're not good at maths?	.294	–
	Which one will tease other kids if they're not good at maths?	.242	–
	Which one will give up when they find a counting problem that is too hard?	.029	–
Statements that boys attributed more to boys in Term 4	Which one expects that they will do well at maths?	-.212	+
	Which one likes it when maths and counting gets a little harder?	-.176	+
	Which one would care the most about doing well in maths?	-.147	+

When considering *who likes it when maths and counting get a little harder* (Figure 5.6A), boys gave the strongest response within the theme of self-concept that this applied to *themselves* in both Term 1 (54%) and Term 4 (43%). This is an interesting comparison to the girls' responses, seeing as the girls were ambivalent regarding this statement. When boys responded to the statement regarding *who would care the most about doing well in maths* (Figure 5.6B), they thought this was more likely to relate to *themselves* in Term 1 (49%), but by Term 4, their most frequent response was that there is *no difference* (40%). Boys decrease their view that this relates to *themselves* (49% in Term 1 to 37% in Term 4) and increase their view that this could relate to girls (15% in Term 1 to 23% in Term 4). When boys considered *which one expects that they will do well at maths* in Term 1 (Figure 5.6C), they most frequently responded with *themselves* (46%). By Term 4, this decreases to 34%, with their most frequent response now being *no difference* (51%).

Boys chose all of the negative statements as relating to the girls. The strongest of these in Term 1 was related to *who will give up when they find a counting problem is too hard* (Figure 5.6D). They responded that this would relate to the girls most frequently in Term 1 (62%). By Term 4, boys still believed this would most frequently relate to girls, although this had decreased to 40%. Boys began to increase the view that they themselves might be more likely to give up when a counting problem is too hard (from 21% in Term 1 to 37% in Term 4). By the end of the year, the strongest of the responses was *which one will get worried if they are* *not good at maths* (Figure 5.6E). In Term 1, the most frequent response was that this would apply to the girls (49%). By Term 4, the most frequent response is tied between girls (43%) and *no difference* (43%). Boys also slightly increase their response that this would relate to *themselves* (from 10% in Term 1 to 14% in Term 4). Boys' response in Term 1 to *who is more likely to tease other kids if they are not good at maths* (Figure 5.6F) is that *girls* are more likely to do this (49%). By Term 4, boys think there is more likely to be *no difference* (40%).

Figure 5.6

Boys' responses to statements relating to self-concept and mathematics in Term 1 and 4.



Note. Green bars represent Term 1 responses. Blue bars represent Term 4 responses. ND = no difference.

5.2.3.2. Children's Perceptions of Gender and Aptitude in Mathematics in Term 1 and Term 4

There are six statements related to aptitude in the *Who and Mathematics* survey (Table 5.10). In Term 1, the girls thought that the statements that they perceived as positive applied to themselves. Girls thought that they would be more likely to *find maths easy* and that they would be more likely to *have to work hard at counting and numbers to get it right.* As discussed earlier, the perception of this statement relies on inferring that the student would have to work hard out of necessity due to a lack of aptitude. It seemed that students perceived this statement as asking about who was more likely to be a hard worker in mathematics.

In Term 1, all of the statements perceived by the girls as negative were applied to the boys. Girls' mean responses in Term 1 showed that they thought boys were more likely to *get the answers wrong* (-0.514), *not be good at maths* (-0.410), *find maths hard* (-0.308) *and need more help in maths* (-0.162).

Table 5.10

Girls' perceptions of gender and aptitude in mathematics in Term 1

Girls' responses on aptitude in Term 1	Statement	Girls' mean (n=39)	Value
Statements that girls attributed more to girls in Term 1	Which one finds maths easy?	.270	+
	Which one will have to work hard at counting and numbers to get it right?	.103	–
Statements that girls attributed more to boys in Term 1	Which one gets the answers wrong in maths?	-.514	–
	Which one isn't good at maths?	-.410	–
	Which one finds maths hard?	-.308	–
	Which one do you think will need more help in maths?	-.162	–

By the end of the year, girls' views mostly remain the same, although the mean response for each statement has decreased considerably (Table 5.11). Notably, the mean responses for statements relating to aptitude have decreased over the school year more than for any other theme. When considering *who finds maths hard*, girls have changed their mean response to *no difference*.

Table 5.11

Girls' perceptions of gender and aptitude in mathematics in Term 4

Girls' responses on aptitude in Term 4	Statement	Girls' mean (n=37)	Value
Statements that girls attributed more to girls in Term 4	Which one will have to work hard at counting and numbers to get it right?	.200	–
	Which one finds maths easy?	.054	+
Statements that girls attributed more to boys in Term 4	Which one isn't good at maths?	-.143	–
	Which one gets the answers wrong in maths?	-.083	–
	Which one do you think will need more help in maths?	-.054	–
Statements that girls are neutral on in Term 4	Which one finds maths hard?	.000	–

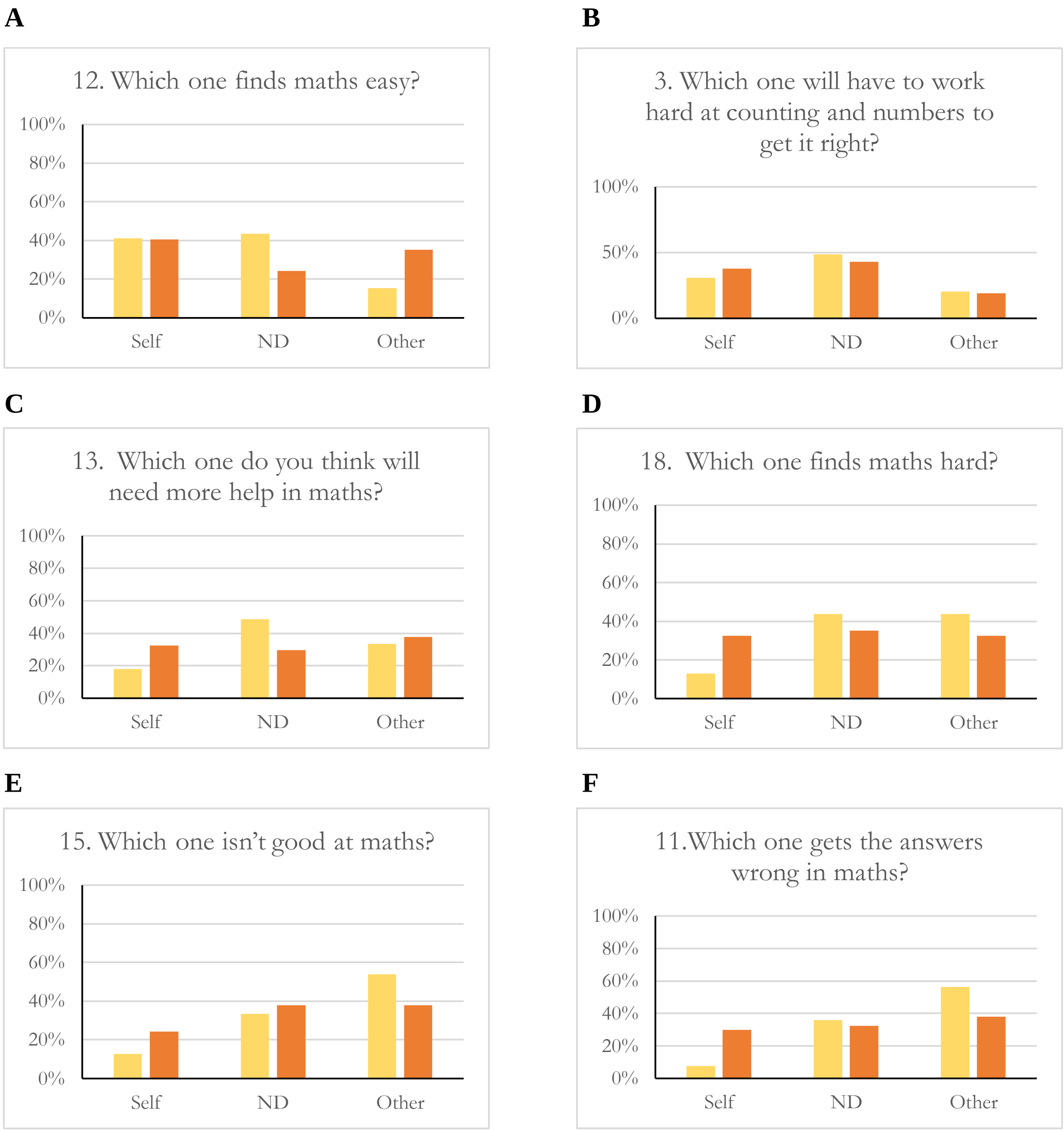
In Term 1, girls thought it was more likely that there would be *no difference* regarding who *finds maths easy*, with 44% of the girls selecting this response (Figure 5.7A). By Term 4, girls have changed their perspectives. When considering the statement *which one finds maths easy,* girls now consider this more likely to relate to *themselves* (41%) rather than the 21% that selected *no difference.* In Term 1, girls also thought that it was more likely to be *no difference* in gender, with 49% of girls selecting this response for the statement *who has to work hard at counting and numbers to get it right* (Figure 5.7B). This did not change greatly across the year as girls' most frequent response by Term 4 was still *no difference* (43%). The response from girls regarding *who needs more help in maths* in Term 1 is that it is most likely to be no *difference* (49%) and is still the most frequent response in Term 4 (38%). These are closely followed by responses showing an increase towards girls over the year, with 32% in Term 4 compared to 18% in Term 1 (Figure 5.7C). Almost triple the number of girls considered that girls *find maths hard* by the end of the year (32% in Term 4 compared to 13% in Term 1) while the response to there being *no difference* (35% in Term 4 to 44% in Term 1) has reduced (Figure 5.7D). Girls most frequent response to *who finds maths hard* in Term 1 is shared equally between boys and *no difference* (44% each). The girls' perspective that boys would *find maths hard* decreased by the end of the year (32% in Term 4 compared to 44% in Term 1) while their response that this relates to *themselves* has more than doubled (from 13% in Term 1 to 32% in Term 4). When girls consider *who isn't good at maths*, they are most likely to select either *no difference* or *boys* with a response of 38% each (Figure 5.7E). They are more critical of themselves in their Term 4 responses (24% in Term 4 compared to 13% in Term 1). However, they are more generous towards boys (38% in Term 4 compared to 54% in Term 1), while the neutral response of *no difference* did not change greatly (38% in Term 4 compared to 33% in Term 1).

The two statements that most girls believed applied to boys were *which one isn't good at maths* with 54% choosing boys and *which one gets the answers wrong* in maths with 56% selecting boys (Figure 5.7E and Figure 5.7F respectively). There are now also more girls who think this might relate more to boys (35% in Term 4 compared to 15% in Term 1). When considering *who gets the answers wrong in maths*, girls still think that this is most likely to apply to boys with a response of 38% (Figure 5.7F). However, they are almost four times more likely to think this statement relates to *themselves* in Term 4 compared to Term 1 (30% and 8%, respectively). There is little change in the percentage of girls who think there is *no difference* (32% in Term 4 to 36% in Term 1), but the girls are more generous towards the boys by Term 4, with 38% of girls thinking boys *get the answers wrong* compared to 56% in Term 1.

When asked in Term 4 who gets the answers wrong, one of the Kindergarten girls, Girl M said that the girls do. She explained this by saying "They (the boys) can get it right and they think it's fun." The extraordinary thing about her statement is that in another interview, when asked who gets the answers right, one of the male students in her class exclaimed, "Girl M! Her and Boy T are the best at maths in the class." Her teacher confirmed that Girl M was the highest achieving student in the class, yet she still considered boys to be the ones who get the answers right.

Figure 5.7

Girls' responses to statements relating to aptitude and mathematics in Term 1 and 4.



Note. Yellow bars represent Term 1 responses. Orange bars represent Term 4 responses. ND = no difference.

Boys' responses to statements regarding aptitude tell a different story to the girls. In Term 1 (Table 5.12), the mean response for each statement shows that boys believe that positive statements are more likely to be representative for boys while negative statements are more likely to represent girls. This is also true in the case of the statement *which one will have to* *work hard at mathematics to get it right.* As discussed in Section 5.2.3, this has been perceived as a positive statement related to work ethic.

When the mean responses for all themes are compared, it can be seen that the strongest three responses from the boys all relate to aptitude. In Term 1, the boys' top three responses for the statements that relate to the girls are that they are *not good at maths* (0.500), *find maths hard* (0.486) and *get the answers wrong in maths* (0.447). The top response in Term 1 for statements associated with boys is also to do with aptitude when boys respond that they are more likely to *find maths easy* (-0.579).

Table 5.12

Boys' perceptions of gender and aptitude in mathematics in Term 1

Boys' responses on aptitude in Term 1	Statement	Boys' mean (n=39)	Value
Statements that boys attributed more to girls in Term 1	Which one isn't good at maths?	.500	–
	Which one finds maths hard?	.486	–
	Which one gets the answers wrong in maths?	.447	–
	Which one do you think will need more help in maths?	.114	–
Statements that boys attributed more to boys in Term 1	Which one finds maths easy?	-.579	+
	Which one will have to work hard at counting and numbers to get it right?	-.179	–

By Term 4, most of the boys' mean responses remain the same (Table 5.13). They continue to believe that they are more likely to *find maths easy* (-0.400), whereas the girls are still *not good at maths* (0.343), *find maths hard* (0.314), *get the answers wrong in maths* (0.286) and *need more help in maths* (0.229). The one statement that has changed across the year relates to which gender *will have to work hard at counting and numbers to get it right*. At the beginning of the year, boys thought that this statement was more likely to be associated with themselves

(-0.179). However, by the end of the year, they have changed to think it represents the girls (0.143).

Boys' top three statements that describe the girls are still to do with aptitude as they continue to think that girls are *not good at maths* (0.343), *find maths hard* (0.314) and *get the answers wrong in maths* (0.286). However, in Term 1, the top statement boys applied to themselves was that they thought *maths is easy*; this is now their second strongest statement (-0.400).

Table 5.13

Boys' perceptions of gender and aptitude in mathematics in Term 4

Boys' responses on aptitude in Term 4	Statement	Boys' mean (n=35)	Value
Statements that boys attributed more to girls in Term 4	Which one isn't good at maths?	.343	–
	Which one finds maths hard?	.314	–
	Which one gets the answers wrong in maths?	.286	–
	Which one do you think will need more help in maths?	.229	–
Statements that boys attributed more to boys in Term 4	Which one will have to work hard at counting and numbers to get it right?	.143	–
	Which one finds maths easy?	-.400	+

When considering *who finds maths easy*, 64% of boys thought this related to *themselves* in Term 1, which decreased to 49% in Term 4 (Figure 5.8A). Boys also increased their view that there is *no difference* between the boys and the girls (43% in Term 4 compared to 28% in Term 1) and maintained their estimation of the girls' abilities (9% in Term 4 compared to 8% in Term 1). When responding to the statement *which one would have to work hard in maths and counting to get it right*, the boys thought this was more likely to relate to themselves in Term 1 with a response of 44% (Figure 5.8B). By Term 4, the most common response was that there was *no difference* (46%). When considering *who needs more help in maths*, the boys most common response in Term 1 is *no difference* (49%). By Term 4, they are less likely to think there is *no difference* between the genders (26%) and increase their view slightly regarding their own need for support (26% in Term 4 compared to 21% in Term 1). There is an increase in their belief that the girls *need more help in maths* in Term 4 (49%) compared to Term 1 (31%) (Figure 5.8C). When considering *which one finds maths hard*, the boys' views showed little change from Term 1 to Term 4. Specifically, 17% of boys think this relates to themselves in Term 4 compared to 13% in Term 1. Boys think there is *no difference* (34%) in Term 4 compared to 28% in Term 1, and 49% believe this applies to girls in Term 4 compared to 49% in Term 1 (Figure 5.8D). The boys' response to *who isn't good at maths* shows that only a small number of boys think this statement applies to themselves, and this perception does not change much over the year (9% in Term 4 compared to 8% in Term 1). They were more likely to think that there is *no difference* between the genders (49% in Term 4 compared to 36% in Term 1) and are more optimistic about girls' abilities in mathematics, with 43% of boys thinking that girls are *not good at maths* in Term 4 compared to 56% in Term 1 (Figure 5.8E). Boy J elaborated on this in the Term 4 interview. After choosing the boys as being *not good at maths*, he was asked why. "Because they (boys) just say it straightaway and they think it's right, and it's not." The researcher followed up to ask if the girls also provide answers straightaway or if they do something different. Boy J said "They do something different… They wait and think"

When responding to the statement *which one gets the answers wrong* boys are reasonably confident in their own mathematical accuracy and do not change their position across the year (14% in Term 4 compared to 13% in Term 1). As the year progressed, they were more likely to select *no difference* between boys and girls (43% in Term 4 to 31% in Term 1). Boys also perceived girls as less likely to *get the answers wrong* in mathematics at the end of the year, with a response of 43% in Term 4 compared to 56% in Term 1 (Figure 5.8F).

Figure 5.8

Boys' responses to statements relating to aptitude and mathematics in Term 1 and 4.

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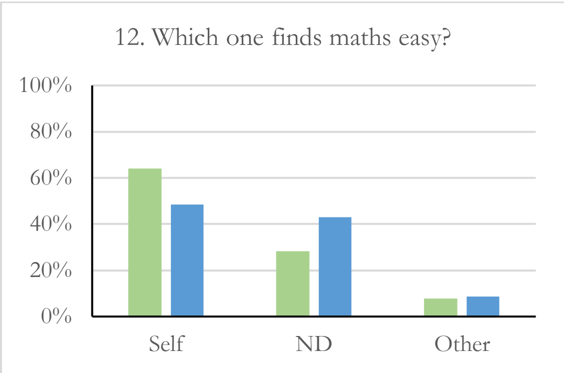

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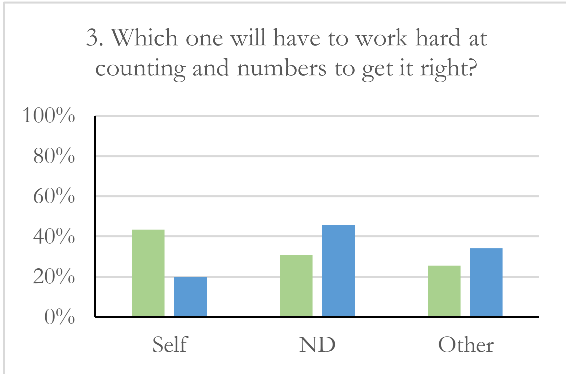

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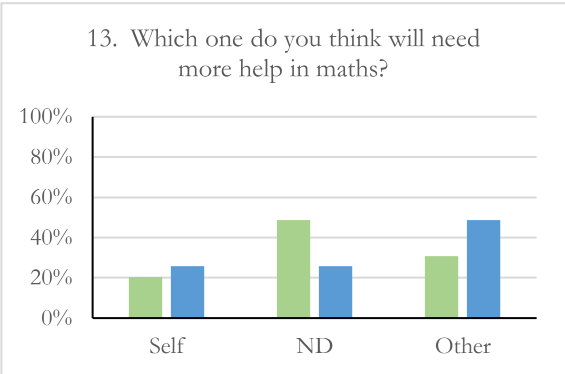

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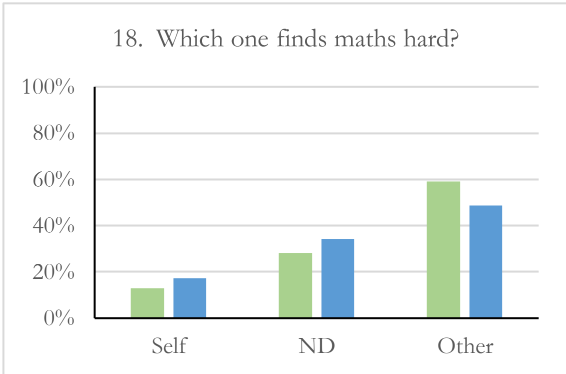

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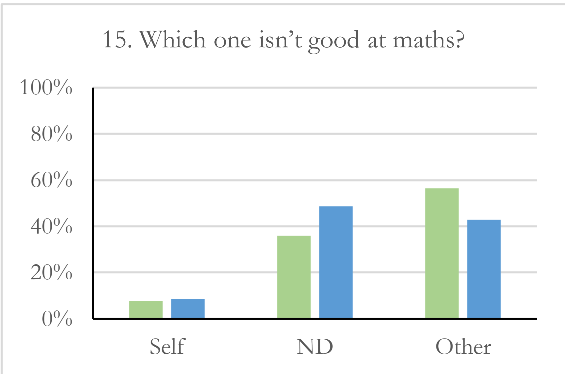

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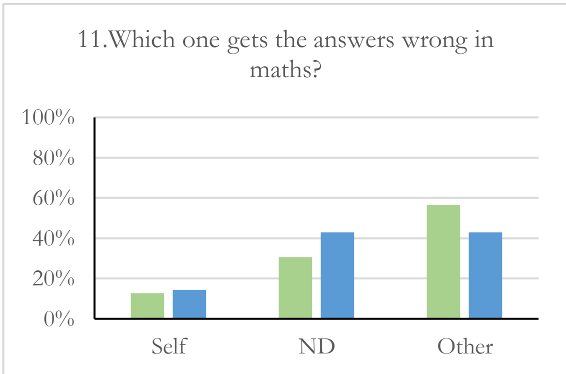


Note. Green bars represent Term 1 responses. Blue bars represent Term 4 responses. ND = no difference.

Overall, boys are more optimistic about girls' aptitude by the end of the year while maintaining confidence in their own aptitude. This contrasts with the trend where girls are more critical of themselves by the end of the year. In Term 4, boys think they are less likely to *find maths easy* and slightly more likely to think boys might *need maths* help. The boys' perspectives remain the same across the year that they are unlikely to *find maths hard*, *get the answers wrong* or not be *good at maths.*

5.2.3.3 Children's Perceptions of Gender and Encouragement from Role Models in Mathematics in Term 1 and Term 4

There was only one statement related to encouragement from role models in the children's version of the *Who and Mathematics* survey. This statement has been misunderstood by many of the children. When asked *which one's parents would be sad or disappointed if they didn't do well in maths,* it seems that the children think the statement is asking which gender does not do well in mathematics, rather than being able to infer that parents may have different expectations of success based on the gender of the child.

When girls were asked this question, they selected boys in both Term 1 (Table 5.14) and Term 4 (Table 5.15). The mean response has decreased over the year from -0.361 to -0.200.

Table 5.14

Girls' perceptions of gender and encouragement from role models in mathematics in Term 1

Girls' responses on encouragement from role models in Term 1	Statement	Girls' mean (n=39)	Value
Statements that girls attributed more to boys in Term 1	Which one's parents would be sad or disappointed if they didn't do well in maths?	-.361	+

Table 5.15

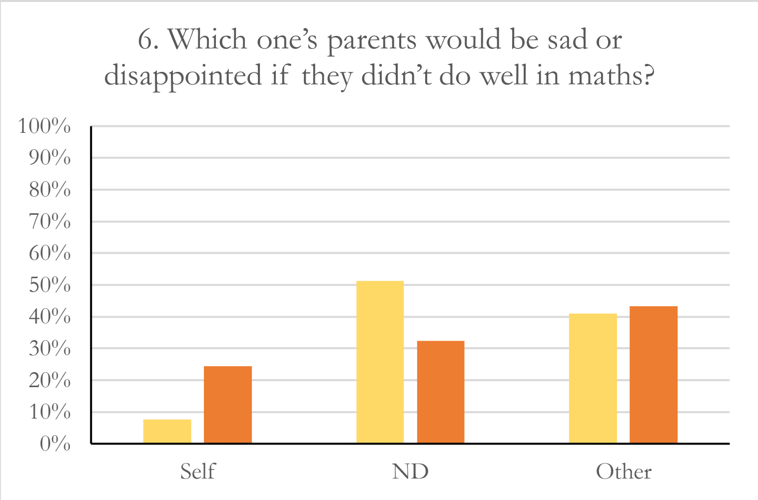
Girls' perceptions of gender and encouragement from role models in mathematics in Term 4

Girls' responses on encouragement from role models in Term 4	Statement	Girls' mean (n=37)	Value
Statements that girls attributed more to boys in Term 4	Which one's parents would be sad or disappointed if they didn't do well in maths?	-.200	+

Girls' responses to the statement *which one's parents would be sad or disappointed if they did not do well at maths* change across the year to thinking this relates to girls more (24% in Term 4 compared to 8% in Term 1), and girls were less likely to respond with *no difference* (32% in Term 4 compared to 51% in Term 1). The girls' views on this statement relating to boys did not change much over the year with responses of 43% in Term 4 compared to 41% in Term 1 (Figure 5.9).

Figure 5.9

Girls' responses to statements relating to encouragement from role models and mathematics in Term 1 and 4.



Note. Yellow bars represent Term 1 responses. Orange bars represent Term 4 responses. ND = no difference.

Boys' views on *whose parents would be sad or disappointed if they did not do well at maths* did not change much over the year either. In both Term 1 (Table 5.16) and Term 4 (Table 5.17), they thought this statement was more likely to relate to girls, which increased slightly in Term 4.

Table 5.16

Boys' perceptions of gender and encouragement from role models in mathematics in Term 1

Boys' responses on encouragement from role models in Term 1	Statement	Boys' mean (n=39)	Value
Statements that boys attributed more to girls in Term 1	Which one's parents would be sad or disappointed if they didn't do well in maths?	.154	+

Table 5.17

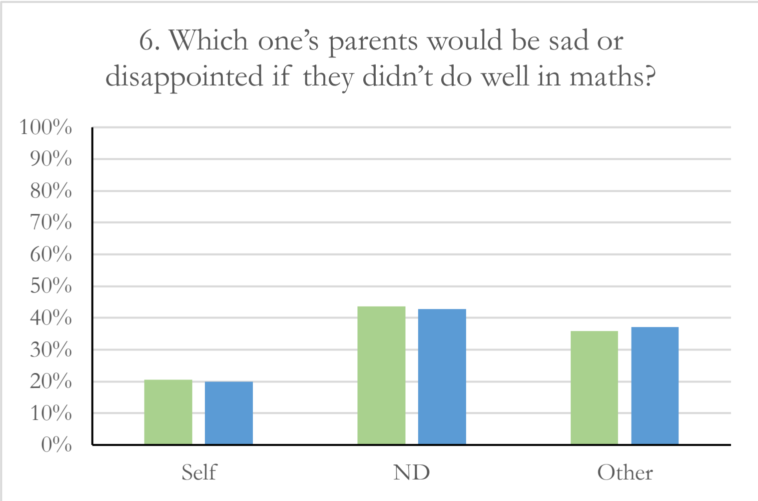
Boys' perceptions of gender and encouragement from role models in mathematics in Term 4

Boys' responses on encouragement from role models in Term 4	Statement	Boys' mean (n=35)	Value
Statements that boys attributed more to girls in Term 4	Which one's parents would be sad or disappointed if they didn't do well in maths?	.176	+

Boys thought it was more likely that there would be *no difference* between the two genders with a response of 43% in Term 4 compared to 44% in Term 1 (Figure 5.10). The next most common response was that it would be the girls' parents that would be *sad or disappointed if they didn't do well in maths.* Their view remained much the same over the year, with a response of 36% in Term 1 and 37% in Term 4. Their view on their own gender being a disappointment to their parents also remained much the same across the year (20% in Term 4 compared to 21% in Term 1). This is the only statement where responses remained virtually the same from the beginning to the end of the year. This is in contrast to the girls' responses to the same statement, where they were three times more likely to nominate themselves by the end of the year when compared to Term 1.

Figure 5.10

Boys' responses to statements relating to encouragement from role models and mathematics in Term 1 and 4.



Note. Green bars represent Term 1 responses. Blue bars represent Term 4 responses. ND = no difference.

5.2.3.4 Children's Perceptions of Gender and Enjoyment in Mathematics in Term 1 and Term 4

There are five statements related to enjoyment (Table 5.18). Girls' mean responses within the theme of enjoyment are some of the strongest out of all of the statements in the *Who and Mathematics* survey. The girls' highest mean score in Term 1 relates to the statement *which one thinks maths is interesting* (0.436). In Term 1, girls thought they were more likely to *think maths is interesting, like using computers to do maths, enjoy maths the most,* and say that *maths is their favourite subject.* These statements had a positive value associated with them, with the exception of the statement regarding the enjoyment of using computers in mathematics. This was considered neutral as it is not necessarily related to the students' relationship with mathematics and is more to do with their interest in using computers. The one negative statement related to enjoyment was *which one thinks maths is boring.* Following the trend of designating negative responses to the other gender, girls thought this would relate more to the boys than to themselves. In addition, this was the strongest mean score in the survey for a characteristic that girls associated with boys (-0.526).

Table 5.18

Girls' perceptions of gender and enjoyment in mathematics in Term 1

Girls' responses on enjoyment in Term 1	Statement	Girls' mean (n=39)	Value
Statements that girls attributed more to girls in Term 1	Which one thinks maths is interesting?	.436	+
	Which one likes using computers to do maths?	.359	+/ –
	Which one would enjoy maths the most?	.263	+
	Maths/ Counting and adding is their favourite	.128	+
Statements that girls attributed more to boys in Term 1	Which one thinks maths is boring?	-.526	–

By Term 4, the girls' responses to the statements still align with all of their Term 1 responses (Table 5.19). However, their mean responses are slightly lower for each of the statements. The statements related to the theme of enjoyment still have the strongest mean scores out of the survey, with the top two statements that girls associate with themselves being *which one thinks maths is interesting* (0.351) and *which one likes using computers to do maths* (0.351). Girls still think boys are more likely to say that *maths is boring*, and it remains the strongest statement out of the survey that girls associate with boys (-0.432).

Table 5.19

Girls' perceptions of gender and enjoyment in mathematics in Term 4

Girls' responses on enjoyment in Term 4	Statement	Girls' mean (n=37)	Value
Statements that girls attributed more to girls in Term 4	Which one thinks maths is interesting?	.351	+
	Which one likes using computers to do maths?	.351	+/ –
	Which one would enjoy maths the most?	.216	+
	Maths/ Counting and adding is their favourite	.081	+
Statements that girls attributed more to boys in Term 4	Which one thinks maths is boring?	-.432	–

In Term 1, one of the most common responses from girls showed that 56% thought they were more likely to *think maths is interesting* (Figure 5.11A). By Term 4, girls were slightly less likely to think *maths is interesting* (51%) and did not think boys would be much more interested in mathematics in Term 4 than they had been in Term 1 (16% in Term 4 compared to 13% in Term 1). In Term 1, 46% of girls thought that they themselves would *like using computers to do maths* (Figure 5.11B). Girls' response to *liking using computers to do maths* shows an increase in their own interest as well as boys' interest in using computers. Girls' responses about their own interest in computers increased to 54% in Term 4 compared to 46% in Term 1, and responses selecting boys were 19% in Term 4 compared to 10% in Term 1. In Term 1, 44% of girls thought they *would enjoy maths the most* (Figure 5.11C). However, girls thought they were less likely to enjoy mathematics by the end of the year (38% in Term 4 compared to 44% in Term 1). They also thought boys would be slightly less likely to enjoy mathematics (16% in Term 4 compared to 18% in Term 1).

Despite these responses, 56% of girls also thought it would be more likely that there would be *no difference* regarding which gender would say *maths is their favourite subject* and despite the decrease in enjoyment, girls were more likely to say that it was *their favourite subject* by the end of the year (41% in Term 4 compared to 28% in Term 1). Girls also thought that boys would be more likely to think it was their favourite subject, increasing 32% in Term

4 compared to 15% in Term 1. They decreased their view that there was *no difference* by 29% over the year as they began to see this as a more gendered statement (Figure 5.11D). When considering who would *find maths boring*, the girls thought this would apply to themselves more by the end of the year (19% in Term 4 compared to 8% in Term 1). More girls also thought the boys would be bored of mathematics by the end of the year (62% in Term 4 compared to 59% in Term 1).

Figure 5.11

Girls' responses to statements relating to enjoyment and mathematics in Term 1 and 4.

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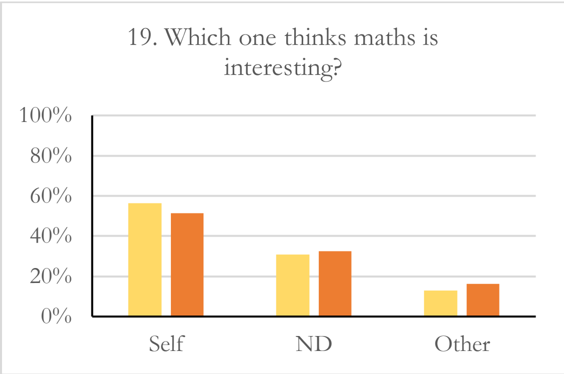

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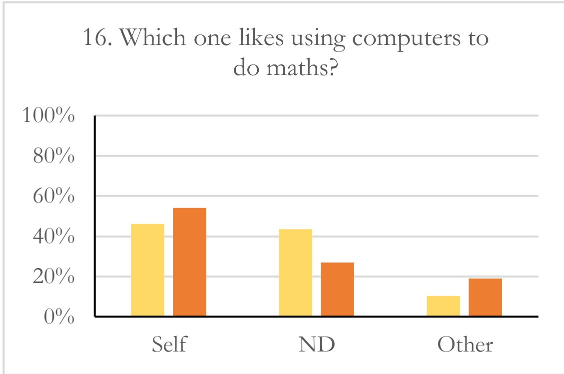

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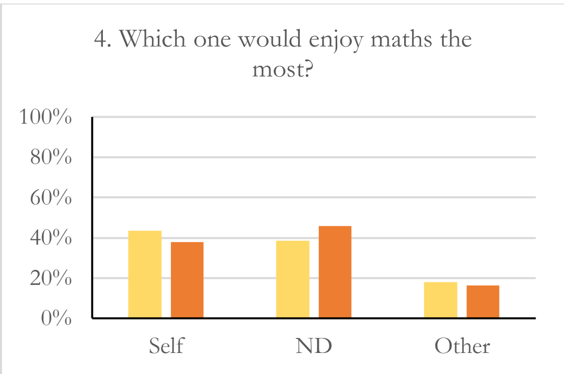

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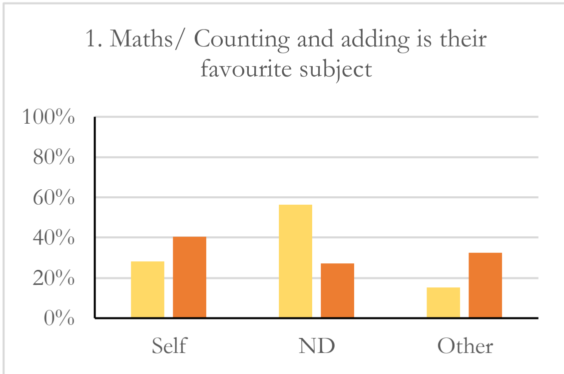

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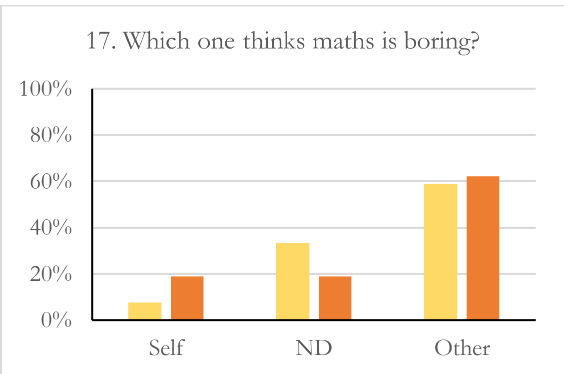

Note. Yellow bars represent Term 1 responses. Orange bars represent Term 4 responses. ND = no difference.

In Term 1, boys responded similarly to girls. For all the statements perceived as positive, they nominated themselves. In keeping with the trend, when they responded to the one negative statement, boys thought it was more likely to be characteristic of the girls. In Term 1, boys thought they were more likely to *think maths is interesting, enjoy maths the most,* say that *maths/ counting and adding is their favourite* subject and *like using computers to do maths.* Boys responded that girls are more likely to *think maths is boring* (Table 5.20).

Table 5.20

Boys' perceptions of gender and enjoyment in mathematics in Term 1

Boys' responses on enjoyment in Term 1	Statement	Boys' mean (n=39)	Value
Statements that boys attributed more to girls in Term 1	Which one thinks maths is boring?	.316	–
Statements that boys attributed more to boys in Term 1	Which one thinks maths is interesting?	-.487	+
	Which one would enjoy maths the most?	-.368	+
	Maths/ Counting and adding is their favourite	-.333	+
	Which one likes using computers to do maths?	-.216	+/ –

In Term 4, the boys remained in agreement with the statements they associated with themselves in Term 1 (Table 5.21). Their views on girls and their enjoyment of mathematics also remained similar over the year. However, the ranking of each of the statements had changed so that in Term 4, the highest mean response was the statement *which one likes using computers to do maths.* The mean response had more than doubled from -0.216 in Term 1 to -0.543 in Term 4. This is a standout to the trend already seen where typically the mean response in Term 4 became more neutral. Boys are also slightly more likely to think that they would consider *maths as their favourite* subject (-0.371 in Term 4 compared to -0.333).

Table 5.21

Boys' perceptions of gender and enjoyment in mathematics in Term 4

Boys' responses on enjoyment in Term 4	Statement	Boys' mean (n=35)	Value
Statements that boys attributed more to girls in Term 4	Which one thinks maths is boring?	.294	–
Statements that boys attributed more to boys in Term 4	Which one likes using computers to do maths?	-.543	+/ –
	Maths/ Counting and adding is their favourite	-.371	+
	Which one thinks maths is interesting?	-.229	+
	Which one would enjoy maths the most?	-.171	–

Boys' most frequent response in Term 1 when considering *who thinks maths is interesting* is that it is a characteristic of boys (54%). Boys thought that mathematics was less interesting by Term 4 (40% in Term 4 compared to 54% in Term 1). They think that girls are more likely to find maths interesting by Term 4 with a response of 17% compared to 5% in Term 1 (Figure 5.12A). Boys' responses increased in Term 4 to select boys as more likely to *like using computers to do maths* (54% in Term 4 compared to 41% in Term 1). Boys also determined by Term 4 that girls were not interested in using computers in mathematics, with a response of 0% in Term 4 compared to 21% in Term 1 (Figure 5.12B). There are no other statements that boys thought did not apply to girls in the interview in either Term 1 or Term 4. Boys' responses on enjoyment in mathematics show they perceive a decrease in their own enjoyment of mathematics (31% in Term 4 compared to 44% in Term 1), whereas they think girls *enjoy mathematics* more as the year progresses (14% in Term 4 compared to 8% in Term 1). More boys thought there would be *no difference* between the genders with responses of 54% in Term 4 compared to 49% in Term 1 (Figure 5.12C). When boys considered *who would say maths/ counting is their favourite subject*, their mean response increased for themselves in Term 4 (46% in Term 4 compared to 38% in Term 1) and increased slightly for the girls (9% in Term 4 compared to 5% in Term 1). Their view that there would be *no difference* between the genders decreased from 56% in Term 1 to 46% in Term 4 (Figure 5.12D).

When considering enjoyment in mathematics, boys follow a similar pattern as their responses on interest and perception of it being a favourite subject. Boys are more frequently selecting *no difference* in Term 4 rather than thinking that a statement is gendered (Figure 5.12E).

Figure 5.12

Boys' responses to statements relating to enjoyment and mathematics in Term 1 and 4.

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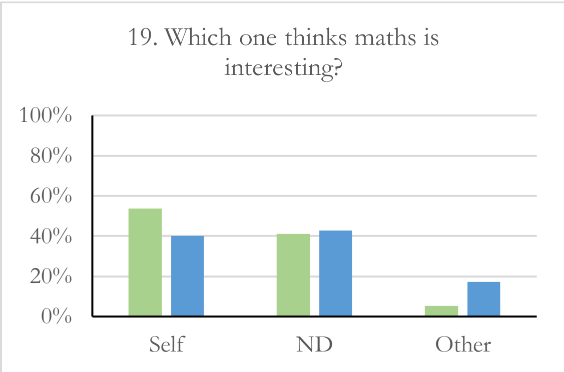

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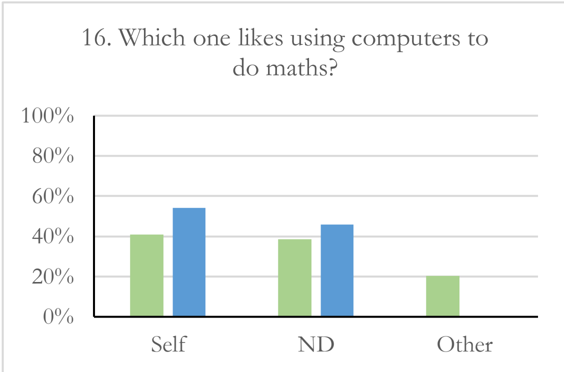

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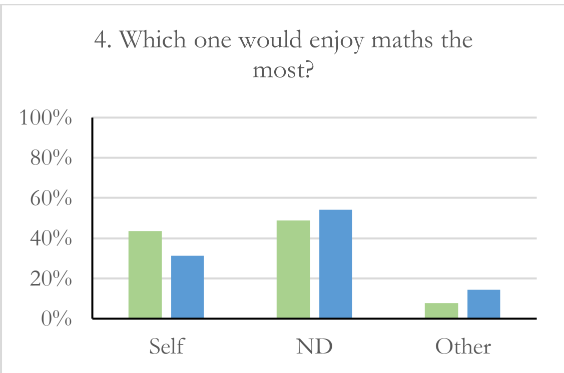

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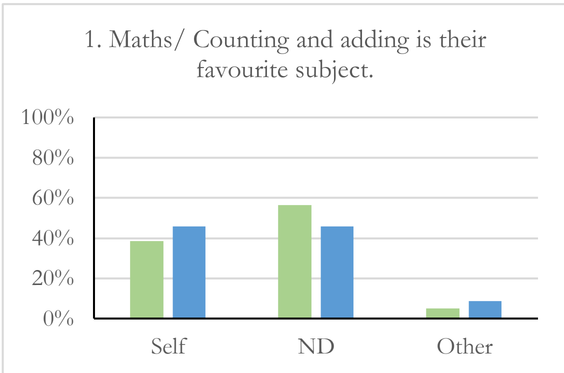

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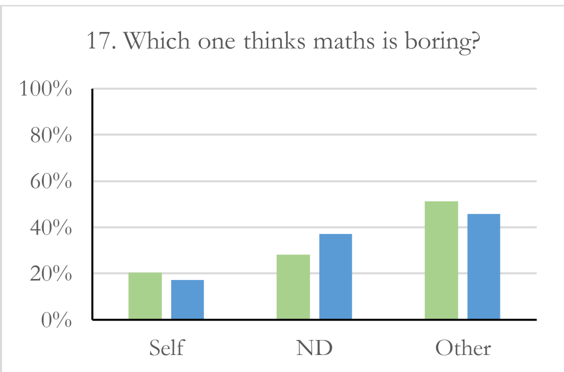

Note. Green bars represent Term 1 responses. Blue bars represent Term 4 responses. ND = no difference.

5.2.3.5 Children's Perceptions of Gender and the Relevance of Mathematics in Later Life in Term 1 and Term 4

There are two statements related to the relevance of mathematics in later life in the children's version of the *Who and Mathematics* survey. In Term 1, girls thought that the statements *which one thinks maths will be more important when they're grown-ups* and *which one needs maths when they grow up and get a job* both applied more to girls than to boys (Table 5.22).

Table 5.22

Girls' perceptions of gender and the relevance of mathematics in later life in Term 1

Girls' responses on the relevance of mathematics in later life in Term 1	Statement	Girls' mean (n=39)	Value
Statements that girls attributed more to girls in Term 1	Which one thinks maths will be important when they're grown-ups?	.194	+
	Which one needs maths when they grow up and get a job?	.061	+

Interestingly, this is the only category containing a statement where girls changed their view about the gender that the statement is associated with between Term 1 and 4. In Term 4 (Table 5.23), girls' mean response increased for the statement relating to the importance of mathematics in later life (0.333 in Term 4 compared to 0.194 in Term 1). On the other hand, the girls' response decreased for the statement regarding needing mathematics to get a job as by Term 4 as they considered this statement more applicable to the boys (-0.162 in Term 4 compared to 0.061 in Term 1).

Table 5.23

Girls' perceptions of gender and the relevance of mathematics in later life in Term 4

Girls' responses on the relevance of mathematics in later life in Term 4	Statement	Girls' mean (n=37)	Value
Statements that girls attributed more to girls in Term 4	Which one thinks maths will be important when they're grown-ups?	.333	+
Statements that girls attributed more to boys in Term 4	Which one needs maths when they grow up and get a job?	-.162	+

The most frequent response for both statements is *no difference*. When considering the importance of mathematics in adult life, more girls thought this applied to them in Term 4 and in Term 1 (41% and 36%, respectively). Correspondingly, 8% of girls thought this applied to boys in Term 4 compared to 18% in Term 1 (Figure 5.13A). When considering *who needs mathematics for when they grow up and get a job,* the responses are quite different (Figure 5.13B). In Term 1, girls responded to this statement with the most agreement in the survey that there was *no difference* between the genders (69%). By Term 4, this had decreased to 51%. Again, a pattern emerges of girls providing gendered responses more at the end of the year when they respond to these statements. When considering their own need for mathematics in future employment, girls did not change their view much over the year (16% in Term 4 compared to 18% in Term 1). However, they have more than doubled their response to boys needing mathematics for employment (32% in Term 4 compared to 13% in Term 1). When asked about this in an interview in Term 4, Girl J chose the boys as needing maths for when they were grown up. She said "They (boys) will do boy stuff, like racing cars and stuff like that. Girls will be hairdressers, yeah, that's what I want to be." While it is not necessarily clear how she perceives racing cars as related to mathematics, she already has a sense of employment opportunities being male or female when she labels some jobs as "boy stuff".

Girl I commented that boys need mathematics for their jobs because "girls can read and boys don't." When asked about the types of jobs that boys will grow up and do, she says "policemans or fire engine (sic)" and thinks that girls can also do these jobs but says that the boys still need more mathematics even when men and women are performing the same roles.

Figure 5.13

Girls' responses to statements relating to the relevance of mathematics in later life in Term 1 and 4.

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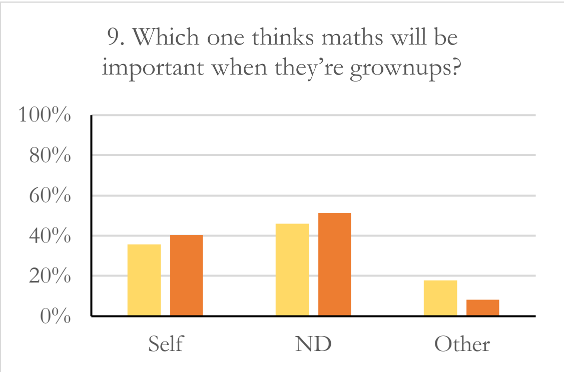

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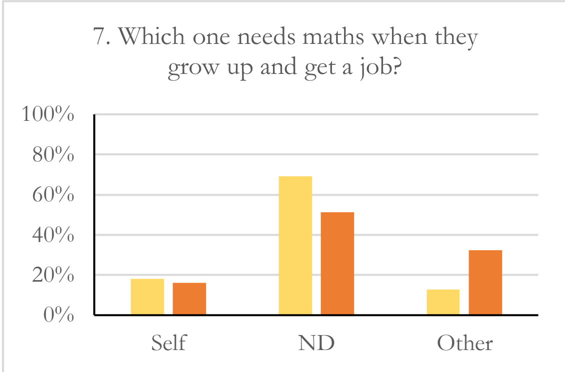


Note. Yellow bars represent Term 1 responses. Orange bars represent Term 4 responses. ND = no difference.

Boys' mean responses remained similar over the year when they considered mathematics relevance in later life. In Term 1, they think that *maths will be important when they're grown-ups* and that they *will need maths when they grow up and get a job* (Table 5.24). By Term 4, they have slightly increased their view on both statements that *maths will be important when they're grown up* and that they *will need maths when they grow up and get a job* (Table 5.25).

Table 5.24

Boys' perceptions of gender and the relevance of mathematics in later life in Term 1

Boys' responses on the relevance of mathematics in later life in Term 1	Statement	Boys' mean (n=39)	Value
Statements that boys attributed more to boys in Term 1	Which one thinks maths will be important when they're grown-ups?	-.152	+
	Which one needs maths when they grow up and get a job?	-.079	+

Table 5.25

Boys' perceptions of gender and the relevance of mathematics in later life in Term 4

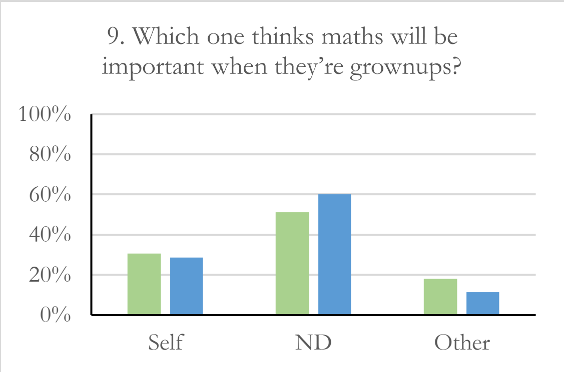
Boys' responses on the relevance of mathematics in later life in Term 4	Statement	Boys' mean (n=35)	Value
Statements that boys attributed more to boys in Term 4	Which one thinks maths will be important when they're grown-ups?	-.188	+
	Which one needs maths when they grow up and get a job?	-.088	+

Boys mostly think there is *no difference* between genders regarding the importance of mathematics in adult life in Term 1. This view increases as the year progresses, with a response of 60% in Term 4 compared to 51% in Term 1. They maintain their view over the year that *maths will be important for them when they're grown-ups* (29% in Term 4 compared to 31% in Term 1), and as the year progresses, boys think mathematics will be less essential for girls in their adulthood with responses of 11% in Term 4 compared to 18% in Term 1 (Figure 5.14A). Boys' views on the requirement of mathematics for employment did not change much over the year either. The majority of boys thought there would be *no difference* between the genders and this increased slightly over the year. (57% in Term 4 compared to 51% in Term 1). As their view increased that there was *no difference* between the genders, there was a corresponding decrease in gendered responses. By the end of the year, boys thought they were slightly less likely to require mathematics for employment (26% in Term 4 compared to 28% in Term 1). They also thought girls were slightly less likely to require mathematics for employment, with responses of 17% in Term 4 compared to 21% in Term 1 (Figure 5.14B).

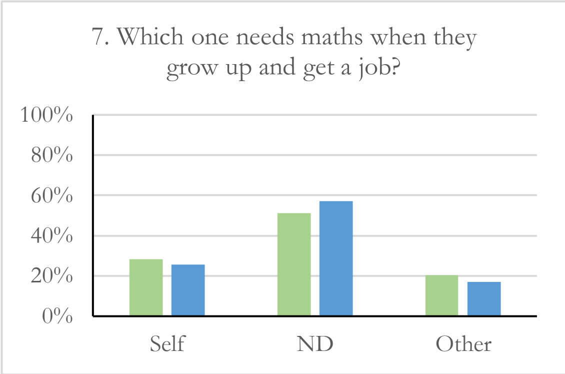
Figure 5.14

Boys' responses to statements relating to the relevance of mathematics in later life in Term 1 and 4.

A



B



Note. Green bars represent Term 1 responses. Blue bars represent Term 4 responses. ND = no difference.

Girls and boys have had very different responses when considering mathematics as adults, particularly concerning its utility to employment. By the end of Kindergarten, boys are more likely to perceive no difference between the genders, whereas girls begin to see mathematics as more important for boys and less critical for girls.

5.3 Comparison of Parents' and Children's Views in Each Theme

To compare the views of parents and children, children's mean responses in Terms 1 and 4 were analysed to see if there was any similarity between parents' and boys' or girls' perspectives. It was previously noted that on average, in Term 1 both boys and girls tended to choose positive statements for themselves and the negative statements for the other gender. To understand children's perspectives more completely, an evaluation of the children's views between the start and end of their first year of formal schooling was completed to see if there was alignment with parents' views. This analysis is discussed through the themes applied to the *Who and Mathematics* survey.

5.3.1 Comparison of Parents' and Children's Views on Self-concept and Mathematics

There are seven statements in self-concept where a comparison of parent and child responses can be made (Table 5.26). Parents thought that girls were more likely to *worry if they* *do not do well in mathematics* (0.213) and boys have agreed with this in Terms 1 (0.405) and 4 (0.294). Girls' views are that boys are more likely to be *worried if they are not good at mathematics* (-0.351 in Term 1 and -0.114 in Term 4). However, both boys' and girls' views shift towards a more neutral response by Term 4. Girls' views showed a greater change, with a difference in the mean response of 0.237 compared to 0.111 for boys. Parents also thought that girls were more likely to *care about doing well in mathematics* (0.197) and *expect to do well in mathematics* (0.115). Since these are both considered positive statements, it is evident that both girls and boys select themselves as more likely to demonstrate these characteristics.

The trend of always selecting positive statements as representative of a child's own gender is not always the case. The parents' mean response for the statement *like challenging mathematics problems* is quite close to being neutral at 0.082, and girls' response is that it is neutral in both Terms 1 and 4, even though it is considered a positive statement. Boys' view this differently and consider the statement to be representative of themselves (-0.368 in Term 1), although their view becomes closer to neutral by the end of the year (-0.176 in Term 4).

When statements that parents thought were more likely to be associated with boys were reviewed, it was clear that they were all considered negative. Similarly, girls nominated the boys as the ones likely to *give up when they find a mathematics problem is too hard* (-0.324 in Term 1 and -0.081 in Term 4), and *tease other kids when they're not good at maths* (-0.500 in Term 1 and -0.389 in Term 4). In turn, boys think these are characteristics of girls. Boys' mean response for *who gives up when they find a mathematics problem is too hard* is girls (0.410 in Term 1 and 0.029 in Term 4) which is the biggest shift from either boys or girls in the theme of self-concept. Boys also think girls are *more likely to tease other kids when they are not good at maths*, although their view does not change as much over the year (0.395 in Term 1 to 0.242 in Term 4). Both boys' and girls' mean responses became more neutral by the end of the year.

Table 5.26

Comparison of parents' and children's mean responses on self-concept in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Worry if they do not do well in mathematics	.213	–.351	-.114	.405	.294
Care about doing well in mathematics	.197	.216	.189	-.361	-.147
Expect to do well in mathematics	.115	.316	.162	-.342	-.212
Like challenging mathematics problems	.082	.000	.000	-.368	-.176
Give up when they find a mathematics problem is too difficult	-.230	-.324	-.081	.410	.029
Tease girls if they are good at mathematics	-.180	-.500	-.389	.395	.242
Tease boys if they are good at mathematics	-.164	-.500	-.389	.395	.242

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

5.3.2 Comparison of Parents' and Children's Views on Aptitude and Mathematics

There are six *Who and Mathematics* statements related to aptitude analysed to compare parents' and children's views to see any similarities (Table 5.27). Parents think that girls are more likely to be represented by the statements *are not good at mathematics* (0.066), *find mathematics difficult* (0.066), *need more help in mathematics* (0.066) and *have to work hard in mathematics to do well* (0.049. Given that these statements can all be considered negative, we again see the trend of both boys and girls choosing the other gender in Term 1. However, some of the statements in the aptitude category show the biggest shifts in view across the year out of any of the themes. Girls and boys both still maintain their views that the other gender *isn't good* *at maths* although they become more neutral in their view as the year progresses. Girls' response to the statement *which one finds maths hard* is notable as they shift their mean response by 0.308 to 0, which is the second-largest shift from girls in the survey. The parents' mean response to this statement is approximately neutral (0.066). Boys also move closer to neutral but there is not as much of a difference between Terms 1 and 4 for the boys as for the girls, with a mean difference of 0.172. When considering *who will need more help in maths*, both boys and girls shift closer to neutral, with girls decreasing their mean response that the statement relates to the boys (-0.162 in Term 1 and -0.054 in Term 4). On the other hand, boys increased their mean response by from 0.114 to 0.229 that this statement is more likely to relate to girls in Term 4 than it did in Term 1. When the responses to the statement *who will have to work hard in mathematics to do well* are viewed, parents think this is approximately neutral (0.049). By Term 4, both boys and girls are in agreement, with girls increasing their response that the statement relates to themselves (0.103 in Term 1 to 0.200 in Term 4), and boys switching their view across the year to agree with the parents (-0.179 in Term 1 and 0.143 in Term 4).

The only statement in the theme of aptitude that parents thought related to boys was *who gets the answers wrong in mathematics* (-0.049). While children do follow the trend of choosing the other gender for a negative statement, the biggest shift in view across the year for this statement is from the girls, with a mean difference of 0.431 from Term 1 to Term 4. While they still believe this relates to the boys, it is notable as their largest decrease in mean response. The boys have also maintained their view that this relates to girls and have shifted towards a more neutral response but not at the same rate as the girls, with a mean difference of 0.161.

The final statement in the theme of aptitude is *who finds mathematics easy*. Parents were neutral, and boys and girls both thought it related more to themselves. However, the boys seem more confident that this relates to themselves with a much greater mean response in both terms (-0.579 in Term 1 to -0.400 in Term 4) compared to the girls' mean response (0.270 in Term 1 and 0.054 in Term 4).

Table 5.27

Comparison of parents' and children's mean responses on aptitude in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Are not good at mathematics	.066	-.410	-.143	.500	.343
Find mathematics difficult	.066	-.308	.000	.486	.314
Need more help in mathematics	.066	-.162	-.054	.114	.229
Have to work hard in mathematics to do well	.049	.103	.200	-.179	.143
Get the wrong answers in mathematics	-.049	-.514	-.083	.447	.286
Find mathematics easy	.000	.270	.054	-.579	-.400

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

5.3.3 Comparison of Parents' and Children's Views on Encouragement from Role Models and Mathematics

There is one statement from the *Who and Mathematics* survey related to encouragement from role models that can be compared between parent and children's views (Table 5.28). Parents responded that it was more likely to be boys' parents that would be *disappointed if they do not do well in mathematics* (-0.115). While parents understood that this statement was related to parent expectation, it is unclear whether children understood this inference. Instead, children tended to interpret this as parent disappointment because they were not good at mathematics and nominated the opposite gender. Girls became more neutral in their response by the end of the year (from -0.361 to -0.200), while boys slightly increased their view that this statement related to girls (0.154 to 0.176).

Table 5.28

Comparison of parents' and children's mean responses on encouragement from role models in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Parents would be disappointed if they do not do well in maths	-.115	-.361	-.200	.154	.176

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

5.3.4 Comparison of Parents' and Children's Views on Enjoyment and Mathematics

There are five *Who and Mathematics* statements related to enjoyment that can be analysed for comparison between parents and children (Table 5.29). Parents think that all of the statements related to enjoyment are more likely to relate to boys. They have responded that *mathematics is their favourite subject* (-0.311), *think mathematics is interesting, enjoy mathematics* (-0.131), *like using computers to solve mathematical problems* (-0.098) and in contrast to their interest and enjoyment, *think that mathematics is boring* (-0.033). Once again, boys and girls aligned themselves with the positive statements and nominated the other gender for the negative statement related to mathematics being boring. In general, both boys and girls became more neutral in their views by Term 4. There are two exceptions to this. Rather than becoming more neutral, boys increase their response to the statement *mathematics is their favourite subject* by the end of the year (from -0.333 in Term 1 to -0.371 in Term 4). This aligned with the parents' response and was the parents' highest mean response within this theme. The other statement within this theme that has not followed the pattern of becoming more neutral by the end of the year is the statement relating to enjoyment of *using computers to work on mathematics problems*. Boys' mean response increased by 0.327 (from -0.216 to -0.543), which is the second-largest shift in response from boys in this study. This aligns with the parent view, although parents did not have such a high mean response as the boys.

Table 5.29

Comparison of parents' and children's mean responses on enjoyment in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Mathematics is their favourite subject	-.311	.128	.081	-.333	-.371
Think mathematics is interesting	-.131	.436	.351	-.487	-.229
Enjoy mathematics	-.131	.263	.216	-.368	-.171
Like using computers to work on mathematics problems	-.098	.359	.351	-.216	-.543
Consider mathematics to be boring	-.033	-.526	-.432	.316	.294

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

5.3.5 Comparison of Parents' and Children's Views on the Relevance of Mathematics to Later Life

There were two statements from the *Who and Mathematics* survey relating to the relevance of mathematics in later life that can be analysed for emerging patterns between the parents and children (Table 5.30). Parents thought that mathematics would be *more important* for the boys *in their adult life* (-0.262) and also that boys were more likely to *need mathematics to maximise future job opportunities* (-0.164). The responses from the children to these statements do not fit the pattern previously seen where views become more neutral as the year progresses. Both boys and girls increase their view by Term 4 that mathematics will be more important in adulthood for their own gender. However, girls change their initial view about the *importance of mathematics for maximising future job opportunities* (from 0.061 to -0.162) and by Term 4 are in alignment with the parents that this statement is more relevant to the boys. The boys thought this statement related to themselves in Term 1 (-0.079) and increased this view by Term 4 (-0.088). This theme is the only one with an alignment of parent and child perspectives, particularly at the end of the year.

Table 5.30

Comparison of parents' and children's mean responses on the relevance of mathematics in later life in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Think mathematics will be important in their adult life	-.262	.194	.333	-.152	-.188
Need maths to maximise future employment opportunities	-.164	.061	-.162	-.079	-.088

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls.

5.4 Summary

This chapter focused on the responses from children and has also compared these to the parents' responses. By contrasting the children's responses with the parents' responses, data has also been shown relating to the research sub-question *What is the relationship between the views that parents and children hold regarding gender and identity?* This next section will summarise the findings of children's and parents' views on gender and mathematics through their responses to the *Who and Mathematics* instrument as categorised by the themes: Self-concept, Aptitude, Encouragement from Role Models, Enjoyment, and Relevance to Later Life. The teachers' responses will be included in Chapter Six.

5.4.1 Children's Views on Gender and Self-concept in Mathematics

Children's responses were similar when they considered the statements relating to self-concept. Of the six statements, both boys and girls chose themselves for the positively valued statements. The only exception to this was that girls were neutral when considering *which one* *likes it when maths and counting gets a little harder*, while boys thought they would enjoy the challenge of harder mathematics. Boys and girls assigned the negatively valued statements to the opposite gender. Both thought the other would *tease other kids if they're not good at maths, will get worried if they're not good at maths*, and *give up when they find a counting problem that is too hard.* By Term 4, the statements that children selected for themselves did not change. However, the mean response had decreased for all statements as children tended to become more neutral in their opinions by the end of the school year.

Parents' responses in this category tended to view boys more negatively. Parents think boys are more likely to be distracting in class and tease other students, while girls are viewed as more likely to care about mathematics and expect to do well. Parents also believe that anxiety about mathematics is more likely to be a characteristic of girls. However, during the first year of school, the girls in this study do not view themselves as anxious. Children at the beginning of the year each expect that their own gender *cares more about mathematics* and *expects to do well* despite the view that parents have that this is more likely to be a characteristic of girls.

In the first year of school, it is not apparent that parents' views have influenced the children's views in the theme of self-concept.

5.4.2 Children's Views on Gender and Aptitude in Mathematics

The theme of aptitude showed the biggest change out of all the themes across the year for girls. Their interview responses to the *Who and Mathematics* statements shows that girls are generally becoming more critical of their own aptitude and at the same time becoming more optimistic about the boys' aptitude in mathematics. By the end of the year, girls think they are more likely to *get the answers wrong*, not be *good at maths*, *find maths hard* and *need more help in maths.* When they consider boys' aptitudes, they think boys are more likely to *find maths easy*, less likely to *get the answers wrong*, less likely to think boys *aren't good at maths*, *find maths hard* or *need more help in maths*. Overall, boys are more positive about girls' aptitude by the end of the year while maintaining confidence in their own aptitude. In Term 4, boys think they are less likely to *find maths easy* and slightly increase their view that boys might *need help in maths*. The boys' perspectives remain similar across the year that they are less likely to *find maths hard*, *get the answers wrong* or not be *good at maths.*

When parents chose a gender rather than *no difference* in the *Who and Mathematics survey,* they tended to respond that the girls do not have a natural aptitude for mathematics and believe they require more support, with the reverse being true for boys. The data showed that parents believe girls are more likely to *have to work hard in mathematics to do well*, *find mathematics difficult*, to not be *good at mathematics*, and *need more help in mathematics*.

Parents and children tend to view the negative statements relating to aptitude as more likely to be characteristics of the girls, and there is some alignment between the parents and children within this theme.

5.4.3 Children's Views on Gender and Encouragement from Role Models in Mathematics

There was only one statement related to encouragement from role models in the children's version of the *Who and Mathematics* survey. Girls thought the statement *which one's parents would be sad or disappointed if they didn't do well in maths* related more to boys in Term 1 and 4, although their mean response decreased to become more neutral by the end of the year. Boys thought this statement related more to girls, and this increased by the end of the year. As previously discussed, it is uncertain whether students at this age were able to infer that this question was to do with parent expectation rather than ability in mathematics.

Parents tended to respond to statements that indicated adult role models would be more encouraging towards boys. Parents responded that boys' *parents think it is important for them to study mathematics*, boys' *parents would be disappointed if they did not do well in mathematics*, boys are *asked more questions by the mathematics teacher*, are *encouraged to do well by the mathematics teacher* and think that the mathematics *teacher will spend more time with them*. Parents were neutral about whom the *mathematics teacher thinks will do well* in mathematics. There is a pattern emerging that the parents believe adult role models in mathematics are better supporting boys.

5.4.4 Children's Views on Gender and Enjoyment in Mathematics

In Term 1, boys and girls both nominate themselves as more likely *to think maths is interesting, like using computers to do maths, enjoy maths the most* and say that *maths is their favourite subject*. They also think the opposite gender is more likely to *think maths is boring.* As their views change across the year, girls' responses to all five statements become more neutral, while boys increase their responses to two of the statements. These are related to the boys' enjoyment of computers which has increased quite a lot and their likelihood to say *maths is their favourite subject* which has increased slightly

Overall, parents see mathematics as more likely to engage boys' interest, even though in the previous sections, parents' responses demonstrated they believe boys are less likely to engage with mathematics as diligently as girls. Parents thought that all five statements regarding engagement related to the boys. They thought boys were more likely to *think mathematics is their favourite subject, think mathematics is interesting, enjoy mathematics* and *like using computers to work on mathematics problems*. Despite this, they also think boys are more likely to *find mathematics boring*. It does not appear that there is a pattern between the parents and children's responses within the theme of enjoyment in mathematics.

5.4.5 Children's Views on Gender and Relevance of Mathematics in Later Life

Both boys and girls increase their view by Term 4 that they think *maths will be important when they're grown-ups.* However, girls change their initial view about the *importance of mathematics for maximising future job opportunities* and by Term 4 believe that this statement is more relevant to the boys. The boys thought this statement related to themselves in Term 1 and increased this view by Term 4. Parents think it is more likely that boys will *think mathematics is important in their later life* and *need mathematics to maximise future employment opportunities*. This theme shows an alignment between parent and child perspectives by the end of the year.

Chapter Six: Presentation of Research Findings from Teachers

6.1 Overview

The focus of this chapter is to report on a preliminary investigation into teachers' perspectives of gender and mathematics. It is scoping in nature as only six out of the potential 11 Kindergarten teachers participated which gives a very small sample size and makes it difficult to draw any conclusions. Teachers of the children who participated in this study were surveyed using the *Who and Mathematics* instrument to see any alignment to the children's responses.

This chapter is organised into two sections. Section One will analyse the teachers' responses to the *Who and Mathematics* survey, noting where the mean tends towards boys or girls. This will be analysed by theme in a similar way to the parent and child analysis. Section Two will then compare the parents', teachers' and children's responses to see any correlations. Finally, the chapter will conclude with a summary of findings.

Table 6.1

Overview of Chapter Six: Presentation of Research Findings from Teachers

6.1	Overview
6.2	Teachers' Perspectives on Gender and Mathematics
6.3	Comparison of Parents', Teachers' and Children's Views in Each Theme
6.4	Summary

6.2 Teachers' Perspectives on Gender and Mathematics

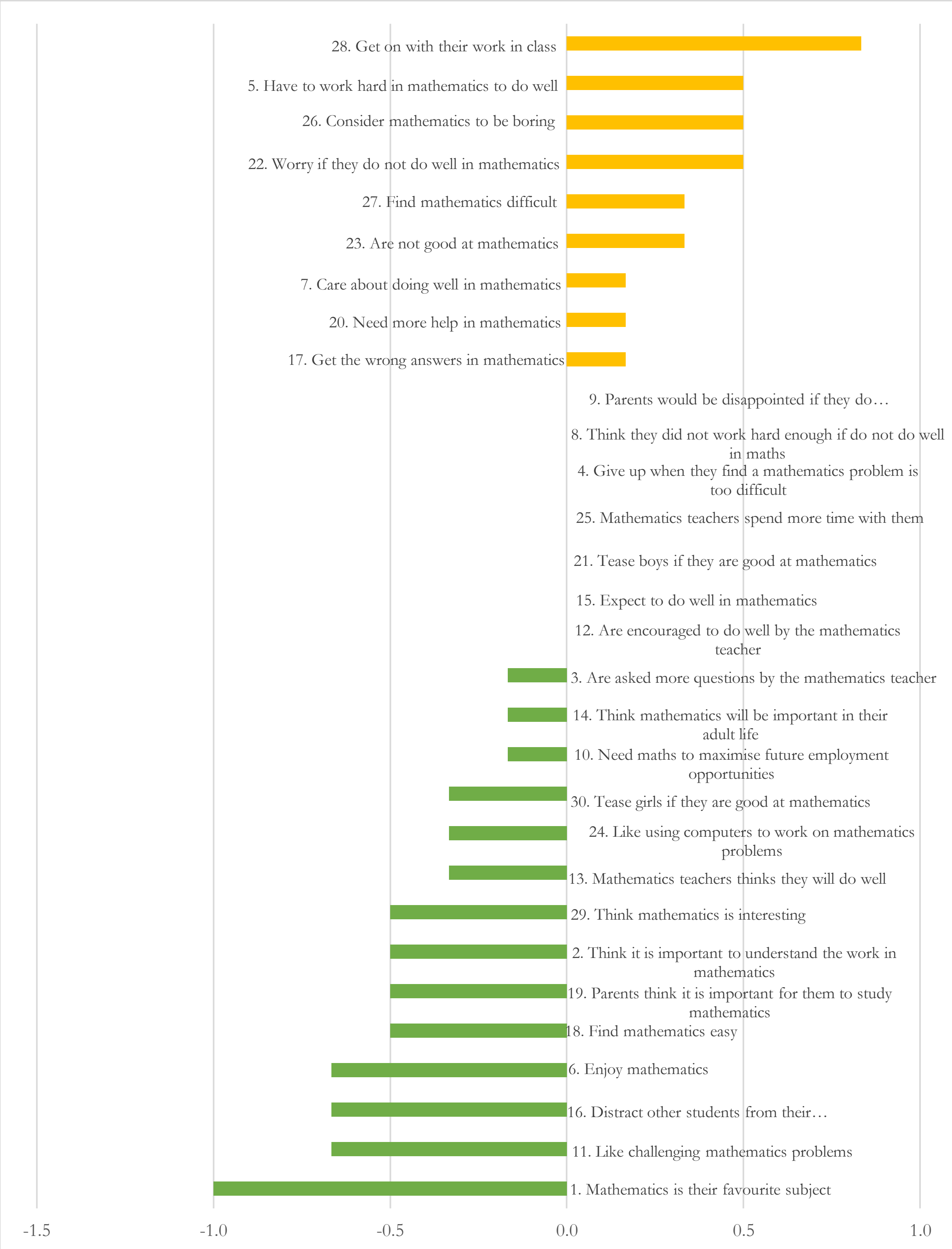
There were six participating teachers for this section of the study, comprising five females and one male. These are the Kindergarten teachers of students who participated in this study reported in Chapter Five. Similar to the parent data analysis, responses in the survey (a five-point Likert scale) were converted into numerical values from -2 to +2. The response 'boys definitely' was assigned -2, 'boys probably' with -1, 'no difference' with 0, 'girls probably' with +1 and 'girls definitely' with +2.

The teachers' mean responses have then been organised to show the statements associated more with boys, girls or neutral (Figure 6.1). The mean response for all statements was between -1.00 and 0.833, where most teachers' responses were *no difference.* The teachers had a wider-ranging mean response than the parents (-0.46 and 0.43), indicating stronger opinions, although given it is from a much smaller sample size, meaning cannot be extrapolated from this. Teachers' mean responses tended towards girls for nine of the 30 statements, boys for 14 statements and neutral for seven statements.

The two statements with the strongest mean response show that teachers think girls are more likely to *get on with their work in class* (0.833) and that boys will think that *mathematics is their favourite subject* (1.0).

Figure 6.1

Teachers' mean responses in the Who and Mathematics Survey



Note. Yellow bars represent teachers' views towards girls, and green bars represent teachers' views towards boys or clear for no difference.

6.2.1 Teachers' Responses to the *Who and Mathematics* Survey Categorised into Gendered Themes

The five themes of self-concept, aptitude, encouragement from role models, enjoyment and the relevance of mathematics in later life were used in this chapter to evaluate the teachers' responses and identify their views of gender and mathematics.

6.2.1.1 Teachers' Perceptions of Gender and Self-Concept in Mathematics

Of the 11 statements to do with self-concept in mathematics, teachers thought that three related to girls, four to boys and the remaining four were neutral (Table 6.2). Teachers' perceptions of girls are that they are hard workers. They think girls are more likely to *get on with their work in class* (0.833). Teachers also thought girls were more likely to *worry if they do not do well in mathematics* (0.500) and *care about doing well in mathematics* (0.167). Of these three statements, two are considered positive, with the third relating to girls being maths-anxious as negative.

Table 6.2

Teachers' perception of gender and self-concept towards mathematics

	Statement	Teachers' mean (n=6)	Value
Statements that teachers attributed more to girls	Get on with their work in class	.833	+
	Worry if they do not do well in mathematics	.500	–
	Care about doing well in mathematics	.167	+
Statements that teachers attributed more to boys	Distract other students from their mathematics work	-.667	–
	Like challenging mathematics problems	-.667	+
	Think it is important to understand the work in mathematics	-.500	+
	Tease girls if they are good at mathematics	-.333	–
Statements that teachers considered no difference between girls and boys	Expect to do well in mathematics	.000	+
	Think they did not work hard enough if do not do well in maths	.000	+/–
	Give up when they find a mathematics problem is too difficult	.000	–
	Tease boys if they are good at mathematics	.000	–

Teachers had mixed views on the way that boys valued mathematics. There are two positive statements: boys are more likely to *like challenging mathematics problems* (-0.667) and *think it is important to understand the work in mathematics* (-0.500). There are also two negative statements. Teachers think boys are more likely to *distract other students from their mathematics work* (-0.667) and *tease girls if they are good at mathematics* (-0.333).

6.2.1.2 Teachers' Perceptions of Gender and Aptitude in Mathematics

There are six statements to do with aptitude in the *Who and Mathematics* survey. Of these statements, teachers thought that most related to the girls and only one related to the boys (Table 6.3).

Table 6.3

Teachers' perception of gender and aptitude in mathematics

	Statement	Teachers' mean (n=6)	Values
Statements that teachers attributed more to girls	Have to work hard in mathematics to do well	.500	–
	Are not good at mathematics	.333	–
	Find mathematics difficult	.333	–
	Need more help in mathematics	.167	–
	Get the wrong answers in mathematics	.167	–
Statements that teachers attributed more to boys	Find mathematics easy	-.500	+

According to the data from this small sample, teachers do not have a favourable view of girls' aptitude in mathematics. There were five negative statements, and teachers tended to select girls for all five of these. They think that girls are more likely to *have to work hard in mathematics to do well* (0.500), *not be good at mathematics* (0.333), *find mathematics difficult* (0.333), *need more help in mathematics* (0.167) and *get the wrong answers in mathematics* (0.167).

For the one positive statement relating to who *finds mathematics easy*, teachers thought this was more likely to relate to the boys (-0.500). Clearly, there is a gendered view that boys have a natural aptitude for mathematics while girls find it inherently difficult.

6.2.1.3 Teachers' Perceptions of Gender and Encouragement from Role Models in Mathematics

There are six statements related to encouragement from role models in the *Who and Mathematics* survey. Teachers did not think any of these related specifically to girls and selected three of the statements as representative of boys and three as neutral (Table 6.4).

Teachers' responses suggest that they think children's role models more readily support boys in mathematics and expect them to do well. Teachers also thought boys were more likely to have *parents that think it is important for them to study mathematics* (-0.500), more likely to have *teachers that think they will do well* (-0.333) and will be *asked more questions by teachers*

(-0.167). Teachers were neutral in their responses to the statements regarding parents that are *disappointed by their child not doing well in mathematics*, *mathematics teachers spending more time with them* and *encouragement from the mathematics teacher*.

Table 6.4

Teachers' perception of gender and encouragement from role models

	Statement	Teachers' mean (n=6)	Value
Statements that teachers attributed more to boys	Parents think it is important for them to study mathematics	-.500	+
	Mathematics teachers thinks they will do well	-.333	+
	Are asked more questions by the mathematics teacher	-.167	+/–
Statements that teachers considered no difference between girls and boys	Parents would be disappointed if they do not do well in maths	.000	+
	Mathematics teachers spend more time with them	.000	+/–
	Are encouraged to do well by the mathematics teacher	.000	+/–

6.2.1.4 Teachers' Perceptions of Gender and Enjoyment in Mathematics

There are five statements related to enjoyment in the *Who and Mathematics* survey. The teachers in this sample have chosen one of these statements as more likely to relate to girls and the remaining four statements as representative of the boys (Table 6.5).

Table 6.5

Teachers' perception of gender and enjoyment in mathematics

	Statement	Teachers' mean (n=6)	Value
Statements that teachers attributed more to girls	Consider mathematics to be boring	.500	–
Statements that teachers attributed more to boys	Mathematics is their favourite subject	-.000	+
	Enjoy mathematics	-.667	+
	Think mathematics is interesting	-.500	+
	Like using computers to work on mathematics problems	-.333	+/–

Teachers do not think girls are as interested in mathematics as boys. For the one statement teachers nominated for the girls, they selected that girls are more likely to *find mathematics boring* (0.500). The remainder of the statements were selected for the boys. These are that boys would choose *mathematics as their favourite subject* (-1.000), *enjoy mathematics* (-0.667), *think mathematics is interesting* (-0.500) and *like using computers to work on mathematics problems* (-0.333).

Similar to the section on aptitude, teachers have chosen only positive statements for the boys and only negative statements for the girls.

6.2.1.5 Teachers' Perceptions of Gender and the Relevance of Mathematics in Later Life

There are two statements relating to the relevance of mathematics in later life in the *Who and Mathematics* survey. Teachers attributed both of these to the boys (Table 6.6).

Table 6.6

Teachers' perception of gender and relevance of mathematics in later life

	Statement	Teachers' mean (n=6)	Value
Statements that teachers attributed more to boys	Think mathematics will be important in their adult life	-.167	+
	Need maths to maximise future employment opportunities	-.167	+

Teachers' responses show that they think mathematics is more important for boys as they get older. They thought *mathematics would be more important in adult life* (-0.167) and that boys would *need maths to maximise future employment opportunities* (-0.167).

6.3 Comparison of Teachers', Parents' and Children's Views in Each Theme

To compare teachers' and children's views on gender and mathematics, mean scores within each theme in the *Who and Mathematics* statements were compared. For interest, the parents' mean responses have also been included as a comparison.

6.3.1 Comparison of Teachers', Parents' and Children's Views on Self-concept and Mathematics

There are seven statements to do with self-concept that teachers and children responded to (Table 6.7). Teachers tended to view girls as harder workers who will *care about doing well in mathematics* but also *worry if they do not do well in mathematics*. Teachers think boys are more likely to *like challenging mathematics problems* and also *tease girls if they are good at mathematics*. The remainder of their responses were neutral. Because boys and girls chose statements for themselves that were positive and the other gender that were negative, there is no alignment with the teachers' and children's responses.

We can see some similarities between the teachers and parents, although teachers have tended to have more neutral responses, with three out of the seven statements receiving neutral responses. The statement that stands out as the most different is the teachers' response to the statement regarding who will *worry if they do not do well in mathematics*. Both teachers and parents believe this to be a girls' characteristic, but the teachers feel more strongly about this with a mean score of 0.500 compared to 0.213 from parents.

Table 6.7

Comparison of teachers', parents' and children's mean responses on self-concept in the Who and Mathematics survey

Statement	Parents' Mean Response	Teachers' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Worry if they do not do well in mathematics	.213	.500	–.351	-.114	.405	.294
Care about doing well in mathematics	.197	.167	.216	.189	-.361	-.147
Expect to do well in mathematics	.115	.000	.316	.162	-.342	-.212
Like challenging mathematics problems	.082	-.667	.000	.000	-.368	-.176
Give up when they find a mathematics problem is too difficult	-.230	.000	-.324	-.081	.410	.029
Tease girls if they are good at mathematics	-.180	-.333	-.500	-.389	.395	.242
Tease boys if they are good at mathematics	-.164	.000	-.500	-.389	.395	.242

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

6.3.2 Comparison of Teachers', Parents' and Children's Views on Aptitude and Mathematics

There are six statements relating to aptitude that both children and teachers responded to in the *Who and Mathematics* survey (Table 6.8). Teachers' mean responses align with the boys' responses to each statement. This is because both teachers and boys responded to all statements that could be perceived negatively as characteristics of girls and the positive statement as characteristic of the boys.

Compared to the parents' views, the teachers have more consistently chosen negative statements for the girls and shown more agreement with higher mean responses for these statements. While parents were neutral regarding who *finds mathematics easy*, teachers thought this was likely to be a characteristic of the boys. Teachers' responses demonstrate a gendered perception that girls do not have a natural aptitude for mathematics, whereas they think the boys are more naturally capable.

Table 6.8

Comparison of teachers', parents' and children's mean responses on aptitude in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Teachers' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Are not good at mathematics	.066	.333	-.410	-.143	.500	.343
Find mathematics difficult	.066	.333	-.308	.000	.486	.314
Need more help in mathematics	.066	.167	-.162	-.054	.114	.229
Have to work hard in mathematics to do well	.049	.500	.103	.200	-.179	.143
Get the wrong answers in mathematics	-.049	.167	-.514	-.083	.447	.286
Find mathematics easy	.000	-.500	.270	.054	-.579	-.400

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

6.3.3 Comparison of Teachers', Parents' and Children's Views on Encouragement from Role Models and Mathematics

There is one statement related to encouragement from role models that both children and teachers responded to in the *Who and Mathematics* survey (Table 6.9). Interestingly, teachers do not have a gendered belief in this theme. Instead, teachers think that parents' expectations for achievement are the same for boys or girls. In comparison, parents think that there is a gendered expectation in favour of the boys.

Table 6.9

Comparison of teachers', parents' and children's mean responses on encouragement from role models in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Teachers' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Parents would be disappointed if they do not do well in maths	-.115	.000	-.361	-.200	.154	.176

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls and beige cells are no difference.

6.3.4 Comparison of Teachers', Parents' and Children's Views on Enjoyment and Mathematics

There are five statements related to enjoyment that both children and teachers responded to in the *Who and Mathematics* survey (Table 6.10). As seen in the previous section on aptitude, teachers' responses align with the boys' responses for all statements. Once again, teachers have selected all negative statements as characteristics of girls, while the positive statements are attributed to boys.

In comparison to the parents, teachers are again more consistent in selecting negative statements for girls and positive statements for boys. There is also greater agreement amongst teachers as all responses have a higher mean.

Table 6.10

Comparison of teachers', parents' and children's mean responses on enjoyment in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Teachers' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Mathematics is their favourite subject	-.311	-1.000	.128	.081	-.333	-.371
Think mathematics is interesting	-.131	-.500	.436	.351	-.487	-.229
Enjoy mathematics	-.131	-.667	.263	.216	-.368	-.171
Like using computers to work on mathematics problems	-.098	-.333	.359	.351	-.216	-.543
Consider mathematics to be boring	-.033	.500	-.526	-.432	.316	.294

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls.

6.3.5 Comparison of Teachers', Parents' and Children's Views on the Relevance of Mathematics in Later Life

There are two statements related to the relevance of mathematics in later life that both children and teachers responded to in the *Who and Mathematics* survey (Table 6.11). As seen in the sections on aptitude and enjoyment in mathematics, teachers' responses aligned with boys' responses. This is the only theme where a switch in view is seen with girls changing their perception that they *need maths to maximise further employment opportunities* in Term 1 to thinking this is a characteristic of boys by Term 4. Within this theme, teachers and parents are also in alignment with their responses.

Table 6.11

Comparison of parents' and children's mean responses on the relevance of mathematics in later life in the Who and Mathematics survey

Parent Statement	Parents' Mean Response	Teachers' Mean Response	Girls' Mean Response T1	Girls' Mean Response T4	Boys' Mean Response T1	Boys' Mean Response T4
Think mathematics will be important in their adult life	-.262	-.167	.194	.333	-.152	-.188
Need maths to maximise future employment opportunities	-.164	-.167	.061	-.162	-.079	-.088

Note. Green cells represent statements with a mean response towards boys, yellow cells towards girls.

6.4 Summary

Based on the teachers' mean responses to the survey, most teachers chose 'no difference. However, where there was a difference, teachers have a gendered perspective that girls are hard workers who lack natural ability. Again, it should be noted that this is a small sample size and should not be applied more broadly, or even as representative of the teachers within the schools in the case study. For all statements relating to aptitude that could be seen as positive, the mean response showed a more favourable response to boys and when teachers perceived a gender difference, they thought that it would be girls who would be more likely to care about their mathematics achievement and be worried if they do not do well. Teachers' mean responses also indicated they thought that boys were more likely to consider mathematics their favourite subject and enjoy it more. When teachers perceived a gendered difference, they thought it would be more likely that boys will need mathematics in their adult life.

In comparison to the parents, teachers were more consistent with their views that boys have a natural aptitude for and enjoyment of mathematics. Furthermore, the teachers' mean responses within the theme of aptitude and enjoyment were also higher than the parents, indicating greater agreement amongst the teacher participants.

Chapter Seven: Discussion

7.1 Overview

Chapter Seven discusses the parents', children's and teachers' responses regarding the subsidiary research questions considering the themes of self-concept, aptitude, encouragement from role models, enjoyment, and relevance to later life. Each theme is discussed through the lens of critical theory to understand the perceived 'realities' of the participants (Cohen et al., 2013). In addition, the parents' interview responses are used throughout to support and provide depth to the analysis. The parents', teachers' and children's responses from both the *Who and Mathematics* instruments and the interview have been essential in informing the discussion in this chapter as well as the recommendations and conclusions in Chapter Eight. The discussion highlights the critical influence that parents and teachers have in informing the learner identity of children during the first year of school. This chapter will culminate with a response to the overarching research question *'How are girls' and boys' mathematical identities being informed as they begin school in Australia?'*

Table 7.1

Overview of Chapter Seven: Discussion

7.1	Overview
7.2	Subsidiary Question One: What are Parents' and Teachers' Views of Girls' and Boys' Mathematical Identities?
7.3	Subsidiary Question Two: How are Boys and Girls Describing Their Mathematical Capabilities and Relationship with Mathematics at the Beginning and End of Their First Year of School?
7.4	Subsidiary Question Three: What is the Relationship Between the views that Parents, Teachers and Children Hold Regarding Gender and Identity?

7.5	How are Girls' and Boys' Mathematical Identities Being Informed as They Begin School in Australia?
7.6	Summary

7.2 Subsidiary Question One: What Are Parents' and Teachers' Views of Girls' and Boys' Mathematical Identities?

In Chapter Two, the reviewed literature showed the historical development of views regarding gender and mathematics. The literature indicated that mathematics had typically been considered a male domain and that girls needed encouragement to participate and engage more readily in mathematics (Leder, 2019a). An increased focus on supporting girls' access and inclusion in the classroom, seen in policy changes and interventions in Australia in the 1990s was established to promote girls' engagement with mathematics. However, there remained both a reduced level of participation by girls in senior years of secondary school (Wienk & O'Connor, 2020) and a commonly held view that mathematics talent is innate and cannot be developed (Leslie et al., 2015). Further to this, the stereotype that boys rather than girls will possess the requisite innate skills needed to succeed in mathematics has remained stubbornly intransigent (Eccles et al., 1990; Tomasetto et al., 2015). Boaler (2015) suggested that mathematics is widely understood to be only for some people and, an innate talent. Much of her work focuses on shifting that mindset, as she has suggested that mathematical identity influences participation and achievement. While results from TIMSS and PISA studies showed no evidence of significant gender differences in mathematics achievement, a perception remains that boys have a more natural affinity and aptitude for mathematics (Kaiser et al., 2012; Lindberg et al., 2010). The literature showed biases from both parents and teachers in favour of boys in which they were viewed as more innately talented while girls had to work hard to address inherent shortcomings (Beilock et al., 2010; Fennema et al., 1990; Tiedemann, 2000). The findings of this current study will next be considered in the themed components of self-concept, aptitude, enjoyment, encouragement from role models, and relevance to later life.

7.2.1 Self-concept

The results of this study showed that overall, parents and teachers were more likely to see girls as hard workers with high expectations, compared to the boys who were perceived as more distracted and less diligent. Parents and teachers also believed girls were more likely to suffer self-doubt and worry about their mathematical ability. Responses showed a preference towards the girls *expecting to do well in mathematics*. This is at odds with their belief that girls *do not do well in mathematics*. Parents and teachers tended to believe that girls have high standards but lack the inherent skills to reach their goals. Overall, twice as many parents believed that girls rather than boys would worry about their results and four times as many parents thought that girls would attribute their poor results to their lack of effort. Parents elaborated on these ideas in the interview. Mother A said "I think in general, from my personal experience, the girls seem to worry a bit more about marks and perfecting, getting the right answer, whereas the boys were more sort of practical, and sort of easy going towards maths."

It appears that the parents and teachers in this current study have perceived a poorer mathematical self-concept in girls which aligns with findings in the research literature (Eccles et al., 1990; Stoet et al., 2016; Tomasetto et al., 2015). Analysis of Year 4 students' TIMMS results in 2015 indicated that both children and their parents were more likely to think girls would have a lesser self-concept in mathematics than boys (Mejia-Rodriguez et al., 2021). Mejia-Rodriguez et al. (2021) attributed this difference in self-concept between the genders to the process of socialisation, and in particular, parents' contribution to this process. It is reasonable to expect that parents with lower mathematical expectations for their daughters than their sons have an impact on their daughters' self-concept. Mejia-Rodriguez et al. (2021) suggested that the poor self-concept demonstrated by Year 4 girls globally required further research to see when girls start to lag behind regarding their mathematical self-concept. This current study introduces new findings to show that parents and teachers have lesser expectations for girls' mathematical self-concept as early as the first year of formal education.

In addition to parents' beliefs that girls have a lesser self-concept, parents and teachers believe that girls are more likely to internalise anxiety about mathematics than boys which is also consistent with the research literature. For example, Vale's 2008 analysis of TIMSS and PISA data from 2000 – 2008 showed no significant differences in mathematical mean scores between boys and girls but drew attention to a notable difference between boys' and girls' anxiety levels. In both TIMSS and PISA assessments, boys and girls were asked to self-assess a range of affective traits including self-confidence, interest, enjoyment, self-efficacy and self-concept. Vale (2008) established that boys rated themselves more highly in all areas but anxiety, which girls were significantly more likely to relate to themselves. The parents and teachers in the current study therefore are accurately describing the reality that girls are more mathematically anxious. To examine this in closer detail though, understanding what parents and teachers attribute this anxiety to would explain more about their views on the mathematical identity of both boys and girls. For instance, if they consider that the anxiety relates to a lesser mathematical ability or that girls are naturally more emotional, then the essentialist and stereotypical view of the way that girls and boys characteristically behave has interpreted their understanding. Exploring the beliefs of parents and teachers to understand why it is that they think girls are more likely to worry about their mathematics results would be worth understanding in a future research study.

Initially it appears that there is a dichotomy with parents and teachers expecting girls to be higher achievers, at the same time as believing girls have less natural aptitude and greater mathematics anxiety. We can relate this construct back to gender essentialism which is a fixed perception that each gender tends toward particular characteristics (Meyer & Gelman, 2016). In both the literature reviewed and the present study, parents and teachers appear to relate mathematical talent more readily to boys. In doing so, the implication is that girls must work harder to close the talent gap. In addition, a stereotypical idea of girls is that they are more likely to be diligent in class than boys (Mendick, 2006) so even when girls do achieve well in mathematics, parents and teachers attribute this to hard work rather than innate talent, which corresponds more readily with their existing preconceptions. Critical theory allows for the possibility of multiple realities (Cohen et al., 2013). So, even though parents and teachers might be presented with information that shows that individual girls or girls more broadly are as mathematically successful as boys, their essentialist constructs can distort this or explain it with stereotypes suggesting this is more to do with hard work than innate talent. Critical theory's 'multiple realities' can therefore explain parents' and teachers' views that girls are hardworking and believe they should succeed in mathematics, simultaneously believing that this is not realistic without additional effort.

Presumably, parents and teachers want all children to have confidence and opportunities in mathematics and not be pigeon-holed by their gender. In that case, they reject the essentialist outlook in which boys and girls are biologically bound to certain characteristics. Nevertheless, in sharing their views of girls as harder workers out of necessity and boys as less diligent because of innate talent, it means they are perpetuating an alternative and unhelpful reality. The impact of this for children in the current study, particularly young girls, is that they begin to describe themselves using stereotypical terminology and acceptance of the status quo by the end of Kindergarten. They are beginning to accept the essentialist perspective and alternative reality that they are less capable in mathematics due to their gender.

Mendick (2006) proposed that identity is constructed and posited that boys' and girls' identities are formed in a simplistic 'either/ or' manner. Someone is either a 'maths person', or they are not. This lack of nuance may be appropriate for children at an early age given that they lack the maturity to fully consider what is in between. However, the hope would be that the influence of adult role models, such as teachers and parents, would encourage less binary and more sophisticated thinking. Instead, this study illustrates that this binary approach to learner characteristics permeates the views of some parents and teachers, specifically in relation to their beliefs about gender identity in mathematics. Further, this study shows that some children are developing similar stereotypical constructs as their views develop and shift across the year to show stereotypical views.

7.2.2 Aptitude

Aptitude in mathematics has traditionally been attributed to males (Fennema, 1974; Leder, 2019). This study shows that this stereotype has prevailed and that there are some parents, teachers and children who view mathematics as a domain that boys are inherently better suited for. Contemporary literature does not support the construct that there are any significant differences between boys' and girls' aptitude in mathematics (Lee & Anderson, 2015; Vale, 2008). However, in addition to showing that this stereotype still exists, this study has also exposed the point in time where children begin to develop these gendered stereotypes and become more closely aligned in perspective with their parents and teachers.

Parents' mean results showed that they tended to think that girls were *not good at mathematics*, *find mathematics difficult*, *need more help in mathematics* and *have to work hard in mathematics to do well*. Compared to the parents' views, the teachers had more consistently chosen negative statements for the girls as well as showing more agreement demonstrated by higher mean responses for these statements. While parents were neutral regarding who *finds mathematics easy*, teachers thought this was likely to be a characteristic of the boys. Teachers' mean responses demonstrated a gendered perception that girls do not have a natural aptitude for mathematics, whereas they thought the boys were more naturally capable. This paints a picture of girls lacking inherent ability, which should correspondingly be connected to underperformance. However, the literature does not support the view that girls underperform in mathematics. The analysis of large-scale data, nationally and internationally, showed that there is no evidence to suggest that gender is a reliable indicator to predict mathematical achievement (Lee & Anderson, 2015; Vale, 2008). The question must be asked then, what is it that parents and teachers base their views on when they consider girls as less capable in mathematics? Seeing as it is not based on any quantifiable information, critical theory points to a constructed reality that is based on incorrect assumptions built on gender essentialist stereotypes. The results suggest that, despite the evidence that boys' and girls' mathematical aptitude and achievement are similar, this view is a stereotype that has stubbornly prevailed.

Parents' and teachers' view of boys' mathematical aptitude in the current study is mainly positive. The only negative statement that parents associated with boys was that they were *more likely to get the answers wrong*. Teachers thought this was more likely to apply to the girls. In light of parents' view that they believed boys would have a greater natural ability in mathematics, this initially does not seem to make sense. When considered alongside parents' views on self-concept, this could be due to parents believing that boys are less dedicated and focused and therefore more likely to submit an answer that has not been carefully thought through. When parents' perceptions of self-concept and aptitude are considered together, a narrative is threaded throughout these data. There is a tortoise and hare view of boys having natural ability and not needing to apply themselves while girls make up for a lack of aptitude with perseverance.

The responses in the current study are similar to what has been reviewed in the literature. That is, parents are more likely to expect boys to be more mathematically successful than girls (Eccles et al., 1990; Gunderson et al., 2012; Tomasetto et al., 2015). In addition, research from Stoet et al. (2016) showed that these gendered messages are passed on from parent to child. Teachers were also found to think that boys would be more mathematically successful (Fennema et al., 1990; Tiedemann, 2000). The implication is that the parents and teachers who believe there is an inherent difference between boys' and girls' mathematical aptitude, are likely to be passing these gendered messages on to children. The consequences for girls are disengagement in mathematics and lesser participation throughout school (Wienk & O'Connor, 2020). Sells' (1980) proposed that mathematics acts as a 'critical filter' allowing only some students access to a range of high-income and high-status careers. Results from this study show that this filtering process begins as early as the first year of school and places serious limitations on young girls and young women as they make choices about which subjects, and later, which careers they choose to pursue.

7.2.3 Encouragement from Role Models

The messaging that children are getting from the role models around them is likely to play a role in developing their mathematical identity (Stoet et al., 2016). The parents and teachers in this current study view girls as having a lesser natural ability than boys in mathematics.

The parents in this current study thought that both parents and teachers would be more supportive of boys and their involvement in mathematics. It is a reasonable assumption that encouragement and support are likely to have an impact on both engagement and self-concept. Parents thought that boys would be more likely to be *encouraged and asked questions by the mathematics teachers* and have *the teacher spend more time with them* in class. The parents also thought that boys' *parents are likely to think it is more important for their sons to study mathematics* and would be *disappointed if they didn't do well,* compared to their daughters.

Teachers' responses suggested that they thought children's role models would more readily support boys in mathematics and expect them to do well. Teachers also thought boys were more likely to have *parents think it is important for them to study mathematics*, more likely to have *teachers who think they will do well* and would be *asked more questions by teachers.* Teachers were neutral in their responses to the statements regarding parents that are *disappointed by their child not doing well in mathematics*, *mathematics teachers spending more time with them* and *encouragement from the mathematics teache*r.

These views play a significant role in the way parents and teachers encourage or demonstrate expectations in mathematics, further reinforcing stereotypical views. Critical theorists would suggest that the 'reality' that is being built here is false and it is also damaging to young girls as they develop their mathematical identities. The false construct developed by parents and teachers that gender determines mathematical aptitude should be confronted. Critical theory tells us that this can assist the development of a new reality based on accurate understandings of achievement (Cohen et al., 2013). In this way, parents and teachers can support students to develop and the way they encourage students is authentic and equitable.

The literature demonstrates that role models can play an essential part in the development of a healthy mathematical identity in children. For example, Gunderson et al. (2012) showed that in high school, parents of boys tended to believe their child had greater mathematical ability and would achieve more than their female counterparts. They proposed that parents can influence students' beliefs and emotional engagement with mathematics. The literature reviewed suggests that role models such as teachers and parents can influence children's attitude to mathematics and the development of their mathematical identity (Stoet et al., 2016). Adding to the body of literature, teachers' and parents' responses showed that there is a lesser belief in the mathematical aptitude of girls. In addition, there is a higher expectation that boys should achieve, and teachers and parents are more likely to reinforce this in the classroom and at home. The implication is that parents and teachers are inadvertently placing limitations on girls which translates to lower participation rates in mathematics at school and later on in the workforce.

7.2.4 Enjoyment

The previous sections focused on self-concept and aptitude and showed that parents and teachers tend to encourage boys more readily due to their own beliefs that males are more inherently talented at mathematics. It is logical that girls will find less enjoyment in a subject that they are being told inadvertently that they are not as talented in, and that they will need to work harder at to keep up with the boys. Both parents and teachers tended towards the view that girls would be less likely to enjoy mathematics which aligns with their perspective that girls also have a lesser aptitude.

Parents in the current study thought that boys would be more likely to *find mathematics interesting* and *enjoyable*, more likely to nominate it as *their favourite subject*, and *more interested in using computers* to work on mathematics problems. A contradictory item in these data is that parents also believe boys are more likely to *find mathematics boring*. Further analysis shows that parents chose boys for all five statements relating to enjoyment. It could be that this is aligned with their view of mathematical self-concept and aptitude, that girls will work hard regardless of what they perceive as a lack of inherent ability and also a lack of interest.

Teachers in this current study also do not think girls are as interested in mathematics as boys. For the one statement teachers nominated for the girls, they selected that girls are more likely to *find mathematics boring*. The remainder of the statements were selected for the boys. These are that boys would choose *mathematics as their favourite subject*, *enjoy mathematics*, *think mathematics is interesting*, and *like using computers to work on mathematics problems*.

Similar to the section on aptitude, teachers' mean responses tend towards positive statements for the boys and negative statements for the girls. Teachers' mean responses imply they do not believe that girls have as much of an interest in mathematics as boys. The research literature supports the view that girls become disengaged with mathematics. The 2008 – 2019 enrolments in senior secondary mathematics in Australia showed that boys in senior secondary school choose mathematics as part of their subject selection more often and, as the difficulty of mathematics increases, the number of girls participating decreases (Wienk & O'Connor, 2020). Chapter two referred to the phenomenon known as 'The Leaky Pipeline' (Simpkins & Davis-Kean, 2005) where girls tend to make choices to disengage in mathematics when they have the option, such as subject selection in high school and university. The current studies' results suggest that girls' disengagement in mathematics occurs at the age of five and that parents and teachers are cognisant of this. The pipeline metaphor currently illustrates the lack of participation in high school and university STEM courses with fewer women entering STEM professions (Kessels & Hannover, 2007). The leaky pipeline metaphor may need to be evaluated to acknowledge disengagement earlier than previously thought. Interestingly, the parents and teachers in this current study already believe that girls are likely to be less engaged in their first year of formal schooling, well before the 'leaky pipeline' is traditionally thought to occur. In relation to critical theory, it is evident that parents have already formed a 'reality' that is based on a stereotypical view. They cannot know at the beginning of the first year of school whether their son or daughter is truly engaged with mathematics before mathematics lessons have begun to take place. In these instances, it is reasonable to suggest parents and teachers are reflecting on their own experience with mathematics or referring to existing stereotypical views and projecting this reality as a likelihood for their children, continuing a narrative that was started long before their child was even born. This became clearer in the interviews as parents often unconsciously began to talk about their educational experiences. When elaborating on who would enjoy mathematics more, parents considered a range of views, noting their own experiences, their child's and other parents. Parents made the following comments during the interview. Father C thought:

> From talking to a lot of other dads that I know their sons are keen on maths and my son is definitely keen on maths and I was as well so that's probably why, yeah, I just think that boys need to be, I think they need to be stimulated a bit more. I think maths is a bit more exciting than English and other stuff.

Mother D agreed when she said “He (Boy J) finds it very interesting. But girls can too, but for me, I think I've seen, a lot of boys find it even more interesting. It's like a competitive thing.”

This study shows that some parents and teachers are modelling the view that girls are not as likely to enjoy mathematics as boys. While the literature supports girls’ disengagement with mathematics later in school (Wienk & O’Connor, 2020), this study shows that boys and girls enjoy mathematics equally at the start of the school year. By the end of the school year, girls are beginning to adjust their responses to show a lesser enjoyment of mathematics. At the same time, boys are starting to increase their responses to show that they enjoy mathematics more by the end of Kindergarten. This appears to be the beginning of the trajectory of disengagement for girls, leading to avoidance later in school and career.

7.2.5 Relevance to Later Life

Parents consider mathematics to be more important for boys as they grow older and for future employment. Just three out of the 61 parents stated that mathematics would be more important for girls, both in adult life and employment. Comparatively, 17 parents responded that boys *needed mathematics in their adult life*, and 14 thought boys needed mathematics to *maximise future employment opportunities*. Teachers’ mean responses show that they also think mathematics is more important for boys as they get older. They thought that *mathematics would be more important in adult life* for boys and that boys would *need maths to maximise future employment opportunities*.

During the follow-up interview, parents also discussed certain careers attracting certain genders: engineering and building for men; office work and nursing for women. The implication being that men are more likely to need mathematics in their careers, which justifies their view that boys require a more meaningful commitment to developing their mathematical skills than girls. There is some truth to this view that career choice is linked to gender. The Australian Bureau of Statistics data between 2016- 2017 showed that there are differences in male and female employment in occupations. For example, almost all jobs worked by machinery operators and drivers were held by males (89.6%), while most clerical and administrative jobs were held by females (76.5%).

Parents in this study have perceived the value of mathematics in relation to the types of careers this might support. Their views are influenced by gender and the types of jobs they believe men and women are typically attracted or suited to. They are encouraging their sons' and daughters' mathematical application, based on current and stereotyped realities, which means that those realities will likely prevail. Until both boys and girls can be encouraged to study mathematics and work in fields that are inherently meaningful to them, without assuming their gender should determine the value of mathematics or which career path they should take, these career divisions will likely continue. The outcome is a lack of diversity in the workplace, particularly in careers where mathematical skills are required. Mother D described the importance of mathematics for boys and girls:

> Maths for boys I found is more important for completing school. If they didn't want to go in an office. I think if girls had to fall back onto a career or what not, they could always fall back into an office, and you've got calculators and that thing, being more literacy types they would need (them). Whereas boys would be in an apprenticeship, building, that sort of hands-on skills where they would need to rely a bit more on maths.

Father B thought the main difference between the genders was the way they were encouraged towards mathematics to gain career opportunities:

> I believe that a lot of parents still will push their boys into doing maths to get further ahead post school. They don't then push girls to do maths just for the same chance. I don't think it'll be the same push to get women to have those opportunities.

The literature shows that parents, teachers and peers played a role in reinforcing gendered roles and vocations (Eccles, 2011). In addition to this, the utility of mathematics is considered by students as they make choices to study mathematics, and at which level (Eccles, 2007; Eccles, 2011). Parents and teachers that endorse the view that mathematics is less useful for girls in later life and in their career are perpetuating a socially endorsed viewpoint that becomes a self-fulfilling prophecy (Eccles, 2011). That is, girls are being told that careers requiring mathematics are more likely to be taken up by boys and so, girls become less likely to participate in these fields. This is not due to a lesser ability, but more so the social and external influences surrounding girls telling them that this is not for them (Eccles, 2011).

7.3 Subsidiary Question Two: How Are Boys and Girls Describing Their Mathematical Capabilities and Relationship with Mathematics at the Beginning and End of Their First Year of School?

7.3.1 Self- concept

Boys' and girls' responses in Term 1 were similar when they considered the statements relating to self-concept. Of the six statements, three were considered positive and both boys and girls chose themselves for two of the positively valued statements. The two statements considered positive were whether students would *care about doing well in mathematics* and *expect to do well in mathematics*. The exception to this pattern of self-selecting for positively perceived statements is that girls were neutral when considering *which one likes it when maths and counting gets a little harder,* while boys thought they would enjoy the challenge of harder mathematics. Boys and girls assigned the negatively valued statements to the opposite gender. Both thought the other would *tease other kids if they're not good at maths, will get worried if they're not good at maths*, and *give up when they find a counting problem that is too hard.* By Term 4, the mean response had decreased for all statements as children tended to become more neutral in their opinions by the end of the school year.

As the children matured by the end of the school year, it is conceivable they began to appreciate the perspective of the other gender and therefore made more considered responses, sometimes choosing the opposite gender for a positive statement and themselves for a negative statement. Presumably, students were able to develop greater nuance in this regard as the year progressed and they developed greater maturity. In addition, they have had the benefit of a year of mathematics lessons and have some sense of which students in the class have performed well, as well as a greater awareness of their own success in mathematics. By the end of the school year and with some maturity and experience of the mathematics classroom, children should be able to deduce more specific conclusions regarding which students are good at mathematics.

An alternative perspective could look at the way the mean response has decreased for both boys and girls. In this study, over one year, the boys' and girls' responses both indicated that they were becoming more neutral. This initially appears to be a positive and non-gendered outcome and a potential rejection of the essentialist perspective. However, this study is not longitudinal and has not been able to capture the trajectory of boys' and girls' ratings of self-concept over a long period of time, so it is also possible that this is capturing the beginning of a shift where either boys, girls or both genders are beginning to change their opinion. To understand this, a further, longitudinal study could be useful to see whether the outcome is a more neutral set of beliefs, or whether this current study has shown the beginning of a trajectory where girls begin to demonstrate the poor self-concept that has been demonstrated by older students in the literature review (Vale, 2008). Cvencek et al. (2011) demonstrated this poor self-concept with Year Two female students when they found that both boys and girls thought that girls would need to work harder to achieve in mathematics. However, this current study demonstrates that children could be developing this understanding earlier. It is conceivable that this is the beginning of the 'leaky pipeline' referred to in Chapter Two as girls begin to believe they must work harder due to a lesser native ability in mathematics, leading to lower participation rates in later years of school. Critical theory encourages an examination of the divergent realities boys and girls are building for themselves.

This study has identified a critical age where children are beginning to assess their capabilities and determine their mathematical self-concept. We can see in these data that students are shifting their views as the year progresses. Providing more long-term data could show this trajectory more clearly. Nevertheless, it is evident that students in this age group are making determinations about their mathematical identity and therefore require consideration at and attention at this age to ensure a healthy and unbiased perspective.

7.3.2 Aptitude

The results regarding aptitude suggest that there is a narrative developing that girls become high achievers in mathematics through effort, while boys become high achievers through innate talent. By the end of the year, when compared to Term 1, girls think they are more likely to *get the answers wrong*, not be *good at maths*, *find maths hard* and *need more help in maths.* When they consider boys' aptitudes, they think boys are more likely to *find maths easy*, less likely to *get the answers wrong*, less likely to think boys *aren't good at maths*, *find maths hard* or *need more help in maths*. Overall, boys are also more positive about girls' aptitude by the end of the year. However, they have maintained confidence in their own aptitude. In Term 4, boys think they are less likely to *find maths easy* and slightly increase their view that boys might *need help in maths*. The boys' perspectives remain similar across the year that they are less likely to *find maths hard*, *get the answers wrong* or *not be good at maths.*

These results are interesting for three reasons; boys and girls have responded differently to one another, implying that there is some experience or transmission of a message leading children to believe that girls are not naturally talented at mathematics, thus developing two different 'realities'. In addition, the responses do not follow the trend previously discussed in *self-concept*, where both boys and girls became more neutral as the year progressed. Finally, this is the first known research to track the deterioration in girls' attitude to their own mathematical capabilities in students this young. While the girls began the year with healthy beliefs that they could achieve and do well in mathematics, the trajectory shifted by the end of the school year in a way that did not occur for the boys. These responses can be compared to a study by Bian et al. (2017) where children, aged five, will describe their own gender as "really, really smart" and "brilliant". By the age of six, girls were significantly less likely to consider themselves brilliant, while boys maintained their view that they were brilliant. In the same study, somewhat surprisingly, girls also thought that they would achieve higher grades than boys. Based on the responses we have seen in this study in the themes of self-concept and aptitude, there is a mathematical identity developing of girls as high achievers through effort, rather than innate 'brilliance'.

7.3.3 Encouragement from Role Models

While this study could not establish how children viewed mathematical messages about their capabilities from role models, there is a great deal of literature discussing how significant adults interact with children and influence their mathematical self-concepts (Stoet et al., 2016). There was only one statement related to encouragement from role models in the children's version of the *Who and Mathematics* survey. Girls thought the statement *which one's parents would be sad or disappointed if they didn't do well in maths*, related more to boys in Term 1 and 4, although their mean response decreased to become more neutral by the end of the year. Boys thought this statement related more to girls, and this increased by the end of the year. It is hard to know whether students have developed the inferential skills required over the year to understand this statement appropriately. Some likely have, and others have not, so this makes it challenging to analyse these data to gain an insight into what children believe about parent expectations in mathematics.

Further research is needed to explore this area more adequately and ensure the suitability of wording in this section of the *Who and Mathematics* instrument for children.

7.3.4 Enjoyment

The study found that out of the four statements relating to positive aspects of the enjoyment of mathematics (*think maths is interesting, like using computers to do maths, enjoy maths the most,* and say that *maths is their favourite subject),* girls had slightly decreased their responses to all four by the end of the year and began to choose these statements as relating more to boys. In contrast, boys increased their view that this was more likely to relate to boys in two statements (*likes using computers to do maths* and *would say maths is their favourite subject*), while the other two became more neutral.

Kaiser et al. (2012) investigated students' beliefs about their perceived mathematical ability in high school. They found that students attributed their ability to their interest in mathematics, with both boys and girls both thinking that boys were more likely to be interested in mathematics. Denissen et al. (2007) showed similar results when they found that a strong predictor of achievement in mathematics was a students' interest and beliefs about their own competence. They observed this in students as young as Year 1. It appears that the trend that Kaiser et al. (2012) and Denissen et al. (2007) have observed in older students may actually begin as early as Kindergarten. This is important as the implication is that enjoyment of mathematics, self-concept and achievement in mathematics are interconnected. The study shows that girls are becoming discouraged in their self-beliefs about aptitude and enjoyment of mathematics as early as Kindergarten. Denissen et al. (2007) assert that this discouragement has an implication for lower achievement throughout school, further fuelling the belief that mathematics is not a domain for girls.

7.3.5 Relevance to Later Life

Both girls and boys are framing employment as gendered at an early age. This is problematic as it places limitations on vocation choice that are based on unhelpful stereotypes. Children at this age cannot have an authentic understanding of workplace demands and so this area is one of the clearest demonstrations of the influence that adult role models have on the views of children.

Students’ results vary in this category. At the beginning of the year, boys had more divergent views on who mathematics would be *important for in later life*. However, by Term 4, boys decreased their perception of the importance of mathematics for both boys and girls, with the selection of *no difference* made more frequently for both statements.

Girls’ responses do not follow the same pattern. Girls’ perception of the utility of mathematics for adulthood remained much the same for themselves as the year progressed (35% in Term 1 to 38% in Term 4). Their perspective on *the importance of mathematics in later life* for boys decreased (from 18% in Term 1 to 8% in Term 4).

However, when girls responded to the statement regarding the *importance of mathematics for employment*, girls' views on the relevance for their own gender only decreased slightly (from 18% in Term 1 to 15% in Term 4), but their belief that boys *need mathematics for employment* is more than doubled (13% in Term 1 to 30% in Term 4). When asked about this in an interview in Term 4, Girl J chose the boys as needing maths for when they were grown up. She said “They (boys) will do boy stuff, like racing cars and stuff like that. Girls will be hairdressers, yeah, that’s what I want to be.” While it is not necessarily clear how she perceived racing cars as related to mathematics, she already had a sense of employment opportunities being male or female when she labelled some jobs as “boy stuff”.

Girl I commented that boys need mathematics for their jobs because: “Girls can read and boys don’t.” When asked about the types of jobs that boys will grow up and do, Girl I says: "policemans or fire engine (sic)" she also stated that she thought girls could also do these jobs but that the boys would still need more mathematics even when men and women are performing the same roles.

The literature established that high-school-aged boys and girls hold different beliefs about the value of mathematics. For example, Thomson et al. (2013) reported that one-fifth of boys did not think mathematics was relevant for future study, whereas one-third of girls held the same belief. Studies by Watt (2005, 2006) attempted to identify the factors that lead to more boys than girls taking higher-level mathematics subjects and intending to forge careers requiring mathematics. Watt (2005, 2006) found that prior success influenced subject choice but not as significantly as students who rated the intrinsic value of mathematics as high. The literature reviewed (Thomson et al., 2013; Watt, 2005, 2006) showed that girls do not always see the utility or value of mathematics. This current study shows girls as young as five years old already framing employment in terms of male and female roles. So, it is possible that in addition to the stereotypes of girls not having a natural aptitude for mathematics, there is an additional stereotype of the type of employment girls and women are likely to move into. In both instances, females are absorbing messages that neither mathematics nor employment involving mathematics is meant for them. Mathematics has been suggested as a critical filter preventing access into high-profile and high-status positions (Sells, 1980). In light of the current study's findings, Sell’s proposition that mathematics acts as the filter does not capture the narrative adequately. Instead, the findings from this study suggest that it is the messages regarding who can be successful at mathematics that act as the deterrent.

Considering this through the lens of critical theory, it is hard to conceive that children at this age have any kind of realistic understanding of workforce demands and so, are unable to create their own reality. Hence, their views are mostly being informed by adults in their lives. As has already been seen, both parents and teachers have some stereotypical beliefs regarding the types of employment men and women are more likely to pursue. These results are exemplifying the stereotypical realities that adults have experienced and pass on. The consequence is that boys and girls are constrained in their choices of vocation by outdated and unhelpful stereotypes.

7.4 Subsidiary Question Three: What is the Relationship Between the Views that Parents, Teachers and Children Hold Regarding Gender and Identity?

This section focused on comparing children’s views between the start and end of their first year of formal schooling and evaluated whether there is alignment with parents’ and teachers’ views. This analysis is discussed through the themes applied to the *Who and Mathematics* survey.

7.4.1 Comparison of Parents’, Teachers’ and Children’s Views on Self-concept and Mathematics

There were seven statements in self-concept in which parent, teacher and child responses were compared. Parent and teacher responses tended to align with the girls’ views in both Term 1 and 4. Parents and girls chose mostly negative statements to represent the boys. Parents and girls thought boys were more likely to *give up when they find a mathematics problem is too hard* and *tease other kids when they’re not good at maths*. Correspondingly, parents and girls chose the remaining positive statements as more likely to represent girls. These were that girls *care about doing well in maths, expect to do well in maths* and *like challenging* *maths problems.* The teachers were not always in agreement with the parents in this theme. Teachers agreed that girls were more likely to *care about doing well in maths* but thought that it would be the boys that would *like challenging maths problems* and were neutral on who would *expect to do well in maths.*

The one exception to the trend of parents thinking girls have better self-concept than teachers is to do with the statement regarding who will *worry if they do not do well in mathematics.* Parents nominated the girls with their strongest mean response within this theme. The teachers' mean response for this statement is higher than the parents (0.500 compared with 0.213). The girls thought this was a statement that represented the boys, although they were less likely to believe this by the end of the year.

The literature supports the idea that mathematics anxiety is much more likely to be characteristic of girls (Ashcraft & Ridley, 2005). Parents and teachers in this study also acknowledged this in their responses. It would be interesting to understand how much of this anxiety stems from the narrative that parents and teachers expect girls to worry more, and therefore normalise the phenomenon.

7.4.2 Comparison of Parents', Teachers' and Children's Views on Aptitude and Mathematics

Six statements related to aptitude were analysed to compare parents', teachers', and children's views. Parents and teachers thought that girls were more likely to be represented by the statements *are not good at mathematics, find mathematics difficult, need more help,* and *have to work hard in mathematics to do well*. Teachers also thought it more likely to be girls who would *get the wrong answer in maths* whereas parents associated this with the boys. Girls thought these statements were representative of the boys; however, they began to adjust their responses to a more neutral viewpoint by Term 4. In this theme, boys', teachers' and parents' views are mostly in agreement as they all consider girls to have a lesser aptitude for mathematics. In fact, the boys make two interesting adjustments to their views as the year progresses. First, they increased their mean response that girls are even more *likely to need help in maths*. Boys also switched their view from Term 1 to Term 4 to say that by the end of the year, they think girls *will have to work hard in mathematics to do well* which they did not perceive at the beginning of the year.

7.4.3 Comparison of Parents', Teachers' and Children's Views on Encouragement from Role Models and Mathematics

There is one statement from the *Who and Mathematics* survey related to encouragement from role models that can be compared to understand parent, teacher and child viewpoints. Parents responded that it was more likely to be boys' parents that would be *disappointed if they do not do well in mathematics.* Teachers were neutral in their response to this statement. While parents understood that this statement was related to parent expectation, it is unclear whether children understood this inference. Instead, children tended to interpret this as parent disappointment because they were not good at mathematics and nominated the opposite gender.

7.4.4 Comparison of Parents', Teachers' and Children's views on Enjoyment and Mathematics

There are five *Who and Mathematics* statements related to enjoyment that were analysed for comparison between parents, teachers, and children. Parents thought that all of the statements related to enjoyment were more likely to relate to boys. Their responses showed they thought boys were more likely to think *mathematics is their favourite subject, think mathematics is interesting, enjoy mathematics*, *like using computers to solve mathematical problems* and in contrast to their interest and enjoyment, *think that mathematics is boring.* Boys mostly agree with the parents with the exception of the statement *considering maths to be boring* which they thought related more to the girls. In comparison to the parents, teachers are again more consistent in selecting negative statements for girls and positive statements for boys. There is also more substantial agreement amongst teachers as all responses have a higher mean, although there was also a small pool of participants. Two statements in which boys increased their view in closer agreement with the parents and teachers are *mathematics is their favourite subject* by the end of the year and *using computers to work on mathematics problems*. Girls' views do not align with parents and teachers within this theme except for the statement *consider maths to be boring* which they selected for the boys. This aligns with the parents' view but not the teachers' view

7.4.5 Comparison of Parents', Teachers' and Children's Views on the Relevance of Mathematics to Later Life

There were two statements from the *Who and Mathematics* survey that related to the relevance of mathematics in later life. These were analysed to see if any patterns emerged between the parents, teachers, and children. Parents and teachers thought that mathematics would be *more important* for the boys *in their adult life* and also that boys were more likely to *need mathematics to maximise future job opportunities.* The responses from the children to these statements do not fit the pattern seen earlier where views became more neutral as the year progressed. Both boys and girls increased their view by Term 4 that mathematics would be more important in adulthood for their own gender. However, girls changed their initial view about the *importance of mathematics for maximising future job opportunities* and by Term 4 were in alignment with the parents and teachers that this statement is more relevant to the boys. The boys thought this statement related to themselves in Term 1 (-0.079) and increased this view very slightly by Term 4 (-0.088). This theme is the only one with an alignment of parent, teacher and child perspectives, specifically at the end of the year. Notably, girls have switched their position over the course of the year regarding the utility of mathematics for employment.

7.5 How are Girls' and Boys' Mathematical Identities Being Informed as they Begin School in Australia?

Throughout this current study, data has been collected and analysed to answer the subsidiary questions:

- What are parents' and teachers' views of girls' and boys' mathematical identities?
- How are boys and girls describing their mathematical capabilities and relationship with mathematics at the beginning and end of their first year of school?
- What is the relationship between the views that parents, teachers and children hold regarding gender and identity?

These three questions culminate to answer the overarching question *How are girls' and boys' mathematical identities being informed as they begin school in Australia?* When boys and girls started their first year of formal education, they were overwhelmingly positive about the capacity of their own gender in mathematics. As the year progressed and children began to absorb what it is to be a mathematics learner and develop their own mathematical identity, these responses changed. The responses in this current study suggest this change in perspective is closely related to significant adult's viewpoints, which play a major role in influencing children's mathematical identity.

Key findings from the study showed that parents' and teachers' mean results tended towards the beliefs that while girls are motivated learners and hard workers, they lack inherent mathematical aptitude. They believe the opposite is true for boys. That is, boys are less focused but more naturally talented in mathematics.

7.6 Summary

In response to the subsidiary question: *What is the relationship between the views that parents, teachers and children hold regarding gender and identity?* Children's responses indicated a change in viewpoint as the year progressed. Between Term 1 and Term 4, children were gradually aligning more with their parents' and teachers' responses. This shows the absorption of these messages regarding mathematical identity. While this study acknowledges in the conceptual framework that there are other sources that children can use to construct their mathematical identity, parents and teachers are instrumental as significant role models.

Based on the parents' and teachers' responses, it was evident adults had a gendered perspective that girls are hard workers who lack natural ability. Parents and teachers tended to choose boys when they considered innate mathematical skills and generally thought that it would be girls who would be more likely to care about their mathematics achievement and become anxious if they are not successful. Additionally, parents and teachers thought that boys would be more likely to consider mathematics their favourite subject and enjoy it more. They also thought it would be more likely that boys would need mathematics in their adult life. Teachers' views were slightly more gendered than the parents' views, however more research should be conducted with a larger participant group of teachers before any conclusive statements could be made.

Overall, it has been established that the parents' and teachers' mean responses tended towards a gendered perspective that favoured boys. It could also be seen that while students began the year without any gendered bias (other than overwhelming positivity towards their own gender), by the end of the year there is an uptake of stereotypically gendered views that aligns with their parents and teachers.

During the interview, the researcher showed the parents the most recent Higher School Certificate (HSC) mathematics enrolments (Table 7.2) (NESA, 2017). Parents were asked to provide their thoughts on the unequal participation rates between males and females. These showed that girls' enrolments in extension mathematics courses were significantly lower than boys (36% compared to 64%) and that across all mathematics courses, there were fewer girls than boys participating, with the exception of Mathematics Standard 2 where girls made up 51% of the cohort.

Table 7.2

Summary of Higher School Certificate Mathematics Course Enrolment (2017)

Course name	Male %	Female %
Mathematics Standard 1	62%	38%
Mathematics Standard 2	49%	51%
Mathematics Advanced	54%	46%
Mathematics Extension 1	60%	40%
Mathematics Extension 2	64%	36%

When parents were asked to comment on why they thought girls were not participating equally in mathematics, every parent had a similar response – that it was a really surprising and disappointing picture of disengagement. Some parents expressed disbelief that these could be accurate statistics and needed to be reassured that the information was accurate and authentic. It was particularly interesting though when parents began to rationalise possible explanations for the lower enrolment rates of girls. Mother A discussed parental views as a potential influence:

> I don't know. My husband is a bit ... sorry if he hears this, but he knows. He's a bit sexist when it comes to boys and maths. I've had to actually really, not sexist, but he's more ... oh boy, because he's the only, he's 48. It's ingrained in him, all boys are good at maths. And I'm always, no, they're not. I don't know if that contributes in any way to what we're seeing now, but he's pointing out. And I say to him, the girls are good at maths too. We're equally good at maths. That concept, I don't know if that has anything to do with it, that concept. But this is really bad. This has got to change. This is like girls in the boardroom. This needs to change. Because this is really bad. Like, I can't ... I

encourage my nieces, like you just, I don't know why they just, is it the ... I don't know, they've got the same brain. Why? Why is this?

Father C of the same Kindergarten student Boy L thought this was more to do with innate ability and diligence from the boys when he states "Because the boys probably, I think they are more, I suppose they just enjoy maths a little bit more and are prepared to work harder. I don't know. I'm not really sure." Mother C also speculated that parent influence was important, at the same time touching on a stereotype of girls as less committed to academic success and more concerned with social success:

> Well, it could be quite a few different factors, it could be their home life too. Some parents push boys harder than they do girls. It could also be that the girls are factoring they want more of a social life than focusing on their studies. So, there's heaps of different factors that you have to think about when it comes in regards to the numbers of are they male or female and having the gender gap I suppose, it regards to this in maths.

The participant, Father B also thought parents were an important influence alongside teachers and discussed gendered expectations of the subject selection that boys and girls might take:

> I would say, partly it has to be influenced by parents and teachers about what kids take. I would say that reflects parents' and teachers' attitudes to what girls should be doing, not necessarily about maths but about what they need to be doing to get into a future academic career. That's what I believe. I would say that it sounds like I'm leaving the students right out of it but I think parents and then teachers play a big part in helping to structure that. It may actually have a lot to do with the push for girls to study things apart from maths after school rather than a desire to do maths or not. Whereas, I don't know. Like I say there were a lot of smart girls at that school but all the guys ... There was that classic model of, oh, you've gotta do physics, you've gotta do chemistry, you've gotta do three or four unit maths to get your marks.

The parents' remarks around the lower rates of HSC mathematics participation show two things. First, superficially at least, they do not believe that girls should be engaging with mathematics any differently than boys. They are saddened to find that girls are disengaging from mathematics more readily than boys, and they can see that this is problematic for girls. Second, in spite of their beliefs that there should be equity, when the parents begin to explore their own values and beliefs, the stereotypical views they hold show that they do believe there are inherent differences between the genders as well as the way society as a whole, and more specifically parents and teachers, nurture and support mathematical talent, based on gender.

These comments offer a neat summary of the data that has been analysed over several chapters.

Chapter Eight: Conclusion

8.1 Overview

This concluding chapter evaluates the scope and purpose of the current study, alongside the findings. These findings resulted in new knowledge and contributions to the field. Recommendations made in this chapter consider the key findings and practical solutions for building healthy mathematical identities in all learning environments. In acknowledgment of the specificity of context in this case, limitations are also considered. Finally, suggestions for further research are noted to complement, support and build confidence in the utility of this study's significant findings.

Table 8.1

Overview of Chapter Eight: Conclusion

8.1	Overview
8.2	Significance of the Findings
8.3	Recommendations
8.4	Limitations
8.5	Opportunities for Further Research
8.6	Final Thoughts

This research shows that parents and teachers in this case hold stereotypical views of boys being inherently better at mathematics with less need of effort to succeed in mathematics. The reverse is perceived for the girls: that they are more likely to work hard, and that this work ethic is necessary because of a lesser natural aptitude. When parents' views were further explored during the interviews, they discussed girls having greater anxiety about mathematics and thought girls generally found mathematics less enjoyable. Parents expanded on the need for boys to participate in mathematics during high-school and to do well as a pre-requisite for employment success, whereas this was less important for girls due to the types of employment with which they think boys and girls would engage. While parents thought that girls *should* achieve and engage in mathematics at the same rates as boys, the data showed that they perceived differences between the genders.

Children's responses in this study were surprising and significant. At the beginning of the year, both boys and girls had a great deal of confidence in their own gender when responding to statements from each of the five identified themes; self-concept, aptitude, encouragement from role models, enjoyment and relevance to later life. At the end of the year, the only area that remained similar was self-concept. Both boys and girls still felt they applied themselves and cared about their mathematics work, although their views were not as strong by the end of the year. In contrast, the most substantial change could be seen in the children's responses to the statements relating to aptitude. By the end of the year, girls thought they were less capable at mathematics and required more help. They believed the reverse to be true for boys whom they perceived to be more naturally talented mathematicians, with a greater likelihood of success. The same shift was not seen in boys' views. They were still very confident in their own aptitude by the end of the school year, which aligned with the parents' and teachers' views that boys are more likely to have a greater natural aptitude for mathematics than girls.

Regarding the theme of enjoyment, girls' responses to all five statements become more neutral, while boys increased their responses to two of the statements as the year progressed. These are related to the boys' enjoyment of computers which increased quite a lot and their likelihood to say *maths is their favourite subject* which increased slightly.

While children’s responses were not able to be adequately gauged regarding encouragement from role models, both boys and girls increased their view by Term 4 that they think *maths will be important when they’re grown-ups.* However, girls changed their initial view about the *importance of mathematics for maximising future job opportunities* and by Term 4 believed that this statement would be more relevant for the boys. The boys thought this statement related to themselves in Term 1 and increased this view by Term 4. Again, this is in alignment to the mean response from the parents and teachers.

8.2 Significance of the Findings

8.2.1 Development of the Children’s Version of the *Who and Mathematics* Survey

The child-friendly adaptation of Leder and Forgasz's 2000 *Who and Mathematics* instrument contributes to the field of mathematics research as future researchers can utilise this version, as required, for young children. This enables comparable studies to take place in different contexts for comparison and contrast. It also allows schools to audit their learners and conduct interviews to find areas of inequity or concern that can then be addressed.

8.2.2 Formation of Mathematical Identities of Children as they Begin Formal Schooling

Prior to this study, there have been no known attempts to investigate what attitudes children bring to school regarding their gender and mathematical identities. There has been a great deal of research conducted on the impact of gender stereotypes and parent and teacher expectations and how they impact children's mathematical self-efficacy and achievement after Year 2 (Eccles et al., 1990; Gunderson et al., 2012; Tomasetto et al., 2015). This is the first time research on mathematical identity has been conducted in the first year of formal schooling. The results suggest that in the first year of schooling these identities are being formed, therefore, any interventions that occur after this first year are in reversing already formed views as opposed to helping children form views. This is very significant regarding the value of interventions regarding negative mathematical experiences. It is important to interrupt and challenge the uptake of negatively and stereotypically gendered views. Ultimately, this could be the key to preventing the phenomenon of the leaky pipeline.

Furthermore, this is the first study to observe changes in perspectives occurring for boys and girls in Kindergarten from the beginning to the end of the year. One of the most surprising results was the way that some of the responses to the themes changed over the year. In Term 1, it appeared that the students did not hold any stereotypical constructs and were very confident about their own gender and their relationship with mathematics. These findings illustrate the point in time where children begin to take on messages about their gender and their capabilities when it comes to mathematics and possibly could have implications for other subjects. Specifically, the girls' perspectives regarding their aptitude and the relevance of mathematics for employment changes from one of positivity to a view that indicates self-doubt about their own aptitude and a lack of relevance for future employment. This current research shows exactly when negative stereotypes begin to be absorbed by children and the rate at which this uptake occurs. It should also be acknowledged that this is a sudden change in less than 12 months which potentially sets the direction for life-long learning.

8.2.3 Three Perspectives: Children, Parents and Teachers

This research is the first to analyse children's views and their primary role models at this age. There is a great deal of research considered in Chapter Two that looked at the views of older children (Thomson et al., 2013, Vale, 2008; Watt, 2005, 2006). Many studies collate data from teachers or parents (Eccles et al., 1990; Gunderson et al., 2012; Tomasetto et al., 2015). This study presents a more comprehensive view of the perspectives that children, their parents and their teachers hold to develop a more holistic view of the influences that form children's mathematical identities. The data indicates that is important to include the children's voice, regardless of their age, to ascertain where the ideas about gender come from, so that appropriate interventions, if necessary, can be designed appropriately.

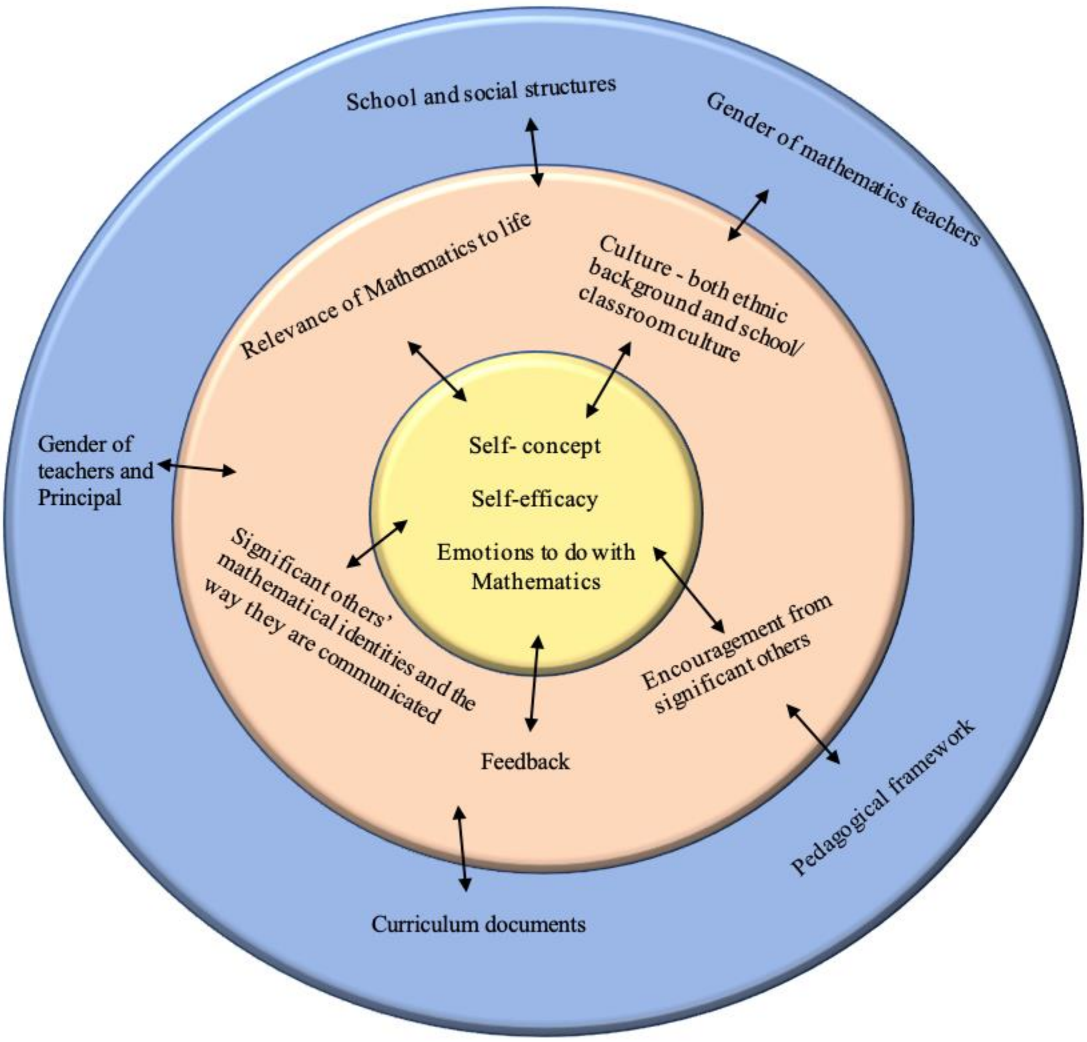
8.3 Recommendations

This study has established that the parents' and teachers' mean responses conformed to stereotypes. Therefore, interventions need to be made to re-direct the perspective of parents and teachers to support boys and girls equitably and this may be the case across many other school settings. There are a number of ways intervention could occur. Initially, schools and classroom teachers could do an audit of mathematical identity in their school using the *Who and Mathematics* instruments to see if there are gendered stereotypes that need to be addressed. While the contextual needs may be different in each learning community, understanding if there are needs to begin with and what they are specifically allow educators and parents to address inequity and consider how mathematical identities can be strengthened for all learners. Importantly, this needs to happen in the early years as the results in this study show that children in Kindergarten are absorbing negative, stereotypical views about their inherent mathematical capabilities.

Using the conceptual framework as a visual tool to identify learning communities' specific influences could also help schools and parents understand which aspects of their community may be unhelpful to learners. For example, acknowledging that in one particular school setting, most teaching staff are female with a male principal, and that this represents a value that is not explicit but has meaning as children begin to determine how they make sense of their own potential. Schools may decide to review the way they provide feedback to acknowledge any bias in their setting. A recording of their mathematics lessons might reveal that they spend more time with one gender over another. By understanding the characteristics and nature of their school setting, considering the influences on mathematical identity shown in Figure 8.1, schools can grapple with inequity in a specific and proactive way. Including parents in these discussions means that all adults are consistent in their support for both genders to develop healthy mathematical identities.

Figure 8.1

The conceptual framework: The multi-layered influences on students' mathematical identity



Encouraging positive communication about mathematics and children's self-perceptions of themselves as competent mathematicians addresses the results showing parents and teachers have diminished expectations for girls' success. Asking parents and teachers to reflect on their own mathematical identity and experiences and asking them to pause and reflect before projecting unhelpful stereotypes means the narrative for young learners can be redirected to be more positive and encouraging.

8.4 Limitations

The limitations of this research include the small sample size and not interviewing the teachers, which could have provided more depth and understanding of their responses.

As hypothesised, there were fewer male parent participants in the study with 11 fathers compared to 50 mothers. Equal representation was an aim but the reality of mothers often being the parent who completes notes and collects their child from school meant that they were the most forthcoming participants.

As in all single case studies, the results from this study are not generalisable to the broader population. The participants' results might differ if the same research was conducted in a different geographical location, such as an inner-city school or a rural school. Other factors such as socio-economic or cultural backgrounds may also impact the results. However, the recommendations could still be considered beneficial and best practice in any situation.

8.5 Opportunities for Further Research

There are opportunities to delve deeper and extend on some of the results and findings in this study. Firstly, to address the limitations of this study, teachers' views could be more intentionally explored with a larger sample size, including follow-up interviews. In addition, more thoroughly interrogating the responses where participants indicated there was 'no difference' could highlight why and where differences occur.

The introduction of the child-friendly *Who and Mathematics* survey would allow researchers to interview young children in other contexts. Addressing the language in the question on role models should be considered so that it is understood appropriately. Currently, the question is *'Which one's parents would be sad or disappointed if they didn't do well in maths?'* This could be expressed more simply as *'Whose parents care more about maths?'*

Exploring the beliefs of parents and teachers to understand why it is that they think girls are more likely to be worried about their mathematics results would also be worth exploring. Is this due to a stereotype and therefore parents expect to see more anxious girls and over report it? Are parents and teachers normalising the phenomenon?

Using the modified child-friendly survey provides valuable opportunities for future researchers to consider several directions that further develop on the elements of the present study. A longitudinal study could take place to see how the student participants' views develop over time which could document the leaky pipeline analogy. We saw the beginning of a shift in direction of views in the Kindergarten participants. Tracking this would be worthwhile to establish whether the trajectory seen in this study continues or plateaus over time. In addition, understanding and exploring children's responses when they thought there was 'no difference' could be beneficial in understanding why some children perceive equity and others do not.

Cultural and socio-economic backgrounds could be explored as a variable such as the research by Barkatsas et al., in 2002 comparing high-school students' responses to the *Who and Mathematics* survey in different countries. Future studies could draw more on an equal balance of parents and attempt to balance the gender of teachers. One element that was not explored was the expertise and breadth of the teachers' experiences. Do these factors impact on stereotypical views?

Drawing on existing research from studies that have utilised the *Who and Mathematics* survey to create a timeline and connect the results could demonstrate changing views over decades and across the world, which would be exciting to capture.

8.6 Final Thoughts

Reflecting on the parents' comments when shown the disparity between girls' and boys' participation in mathematics in the NSW Higher School Certificate, there was a view from parents and teachers that there should be equity and equality between the genders. The ideology of equal opportunity for boys and girls is also referred to in the interviews. However, with some analysis of the responses, parents' views have been influenced by long-standing stereotypical beliefs and they do not support their own rhetoric. Parents and teachers view girls as innately different to boys; girls are harder workers, less capable mathematicians, have higher standards, greater anxiety, a lesser need to pursue mathematics for their careers, which are likely to be different to the boys, and are less mathematical.

This distinction between ‘what is’ and ‘what can be’ is also made in critical theory with the notion of different realities (Cohen et al., 2013). In this instance, parents have articulated the difference between the reality that *is* and the reality that *should be*. It is the intention of critical theory to transform the status quo and move away from the inequitable reality towards the ideal reality that the parents have expressed.

Thinking back over my career as a classroom teacher and my experience with the mother of the Year Four student who ignited my interest in this research, I wonder if her daughter followed the well-trodden trajectory of disinterest and ultimately disengagement in mathematics? She would be completing Year 10 now and making choices about subject selection for the HSC. If her mother has continued to believe that a distinct biological difference will impede her from success in mathematics, then perhaps as they discuss subject selection, her mother will tell her not to worry about taking mathematics, perhaps the humanities are more her thing? And, it’s probably not important for the job she wants to do, anyway. I wonder what could have been possible if, when that student began Kindergarten, parents and teachers were appropriately advised about the equal capabilities of students, with no difference between the genders. Maybe her mother would have rethought some of her comments about the mismatch of mathematics for her daughter, being a 'girly girl'.

After successfully completing three spaceflights Astronaut Chris Hadfield has said, “The best antidote for fear is competence” (Hadfield, 2020). Correspondingly then, feeling incompetent leads to being fearful. If there is a belief about inherent incompetence, the corresponding mathematics anxiety seen in the literature is understandable and avoidable. Perhaps the trajectory for girls in mathematics could be quite different if the aim and the sights are set much earlier on.

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Appendices

Appendix A: Participant Information Sheet

PARTICIPANT INFORMATION SHEET

Exploring Early Years Mathematical Understandings

Dear Parents/ Caregivers,

You and your child are invited to participate in the research project described below. There are three ways the researcher will be collecting data – through a parent survey, a follow-up parent interview and also, an interview with your child. You may choose to commit to one, two or all three of these processes. As a way of saying thank you for your time, **3 X $100 Coles gift cards** will be given away in a random draw. You are automatically included in this draw when you agree to participate in either the survey, parent interview or student interview. The more you participate, the more chances you have to win.

What is the project about?

This research project is about understanding if boys and girls begin school with an understanding that, because of their gender, they are more, less or equally capable in mathematics than the opposite gender.

Who is undertaking the project?

This project is being conducted by Rachelle Glynn and will form the basis for the degree of Doctor of Philosophy at The University of Notre Dame Australia, under the supervision of Timothy Perkins, Dr. Thuan Thai and Dr. Linda Bellen from the School of Education.

What will my child be asked to do?

Your child will be asked questions regarding what they think about maths. This is designed to collect data about whether they think boys or girls are stronger at maths, or whether there is no difference. This interview will take about 10 minutes to complete. It will be audio-recorded and **parents are invited to attend if they wish**. They may be asked for a second interview at the end of the school year to compare their understandings and how they may have changed.

In addition, student Best Start data will be analysed. It is important to note that the researcher is looking at averages across a group of students rather than specific information about your child.

What will I be asked to do?

You are invited to take part in an **online questionnaire** to explore your own experiences with maths. It should take no longer than 10 minutes. Your name will be collected for the purposes of pairing your responses to your child's (if they also take part in an interview). When results are published, your name will be removed and a pseudonym will be applied.

In addition, you are invited to take part in a **follow up interview** to further explore your views on mathematics and gender. This should take no longer than 30 minutes and your identity will be protected with a pseudonym.

Are there any risks associated with participating in this project?

There are no specific risks anticipated with participation in this study. You and your child are able to choose to not respond to questions if preferred. You and your child can also withdraw at any time during the questionnaire or interview, for any reason.

Appendix B: Consent Form for Child Participants (signed by parents)

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

CONSENT FORM: Please return to the Kindergarten teachers

Exploring Early Years Mathematical Understandings

- ☐ I agree to allow my child to take part in this research project, understanding that this is completely voluntary.
- ☐ I have read the Information Sheet provided and been given a full explanation of the purpose of this study, the procedures involved and of what is expected of my child.
- ☐ I understand that my child will be asked to provide their opinion on questions about maths and who they think is good at maths.
- ☐ I understand that the researcher will also be reviewing the school's Best Start Data, looking at general information such as averages between boys and girls.
- ☐ I understand that the researcher will ask my child if they would like to participate. If my child does not want to take part, the interview will not go ahead and there will be no coercion to participate.
- ☐ The researcher has answered all my questions and has explained possible problems that may arise as a result of my child's participation in this study.
- ☐ I understand that my child may withdraw or that I may withdraw my child from the research project at any time without the need for an explanation.
- ☐ I understand that all information provided by me or my child is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.
- ☐ I agree that any research data gathered for the study may be published provided my name or my child's name or other identifying information is not disclosed.
- ☐ I understand that research data gathered may be used for future research but my name or my child's name and other identifying information will be removed.

Name of parent/guardian			
Phone number:			
Name of Child:			
School:			
Signature of parent/guardian		Date	

- ☐ I confirm that I have provided the Information Sheet concerning this research project to the above participant, explained what participating involves and have answered all questions asked of me.

Signature of Researcher		Date	24.10.2017

Consent Form template June 2015 1

Appendix C: Consent Form for Parent and Teacher Participants

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

CONSENT FORM

Exploring Early Years Mathematical Understandings

- ☐ I agree to take part in this research project.
- ☐ I have read the Information Sheet provided and been given a full explanation of the purpose of this study, the procedures involved and of what is expected of me.
- ☐ I understand that I will be asked to participate in a semi structured interview which will be audio recorded
- ☐ The researcher has answered all my questions and has explained possible problems that may arise as a result of my participation in this study.
- ☐ I understand that I may withdraw from participating in the project at any time without prejudice.
- ☐ I understand that all information provided by me is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.
- ☐ I agree that any research data gathered for the study may be published provided my name or other identifying information is not disclosed.

Name of participant			
Signature of participant		Date	

- ☐ I confirm that I have provided the Information Sheet concerning this research project to the above participant, explained what participating involves and have answered all questions asked of me.

Signature of Researcher	R. G[signature]	Date	

Consent Form template June 2015

Appendix D: *Who and Mathematics* Survey

To what extent are the gendered constructs of parents having an impact of girls' self-efficacy in mathematics as they begin school in Australia?

By completing this questionnaire:

- I agree to take part in this research project.
- I have read the Information Sheet provided attached and been given a full explanation of the purpose of this study, the procedures involved and of what is expected of me.
- I understand that I am being asked to complete this questionnaire
- The researcher has answered all my questions and has explained possible problems that may arise as a result of my participation in this study.
- I understand that I may withdraw from participating in the project at any time without prejudice.
- I understand that all information provided by me is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.
- I agree that any research data gathered for the study may be published provided my name or other identifying information is not disclosed.
- I understand that research data gathered may be used for future research but my name and other identifying information will be removed.

* Required

1. **By clicking this box, I am acknowledging that I have read these requirements and consent to participate in this questionnaire.** *

   Check all that apply.

   ☐ Yes

2. **Your gender** *

   Mark only one oval.

   ◯ Male
   ◯ Female

3. **Your child's gender (the child in Kindergarten)** *

   Mark only one oval.

   ◯ Male
   ◯ Female

Who and Mathematics questionnaire

Thank you for taking the time to complete this questionnaire. Please respond to the statements with
BD= Boys definitely
BP= Boys probably
ND= No difference between boys and girls

GP= Girls probably
GD= Girls definitely

e.g. Statement: Is more likely to enjoy reading.
My response is GP as in my experience, girls tend to enjoy reading more than boys.

4. **Mathematics is their favourite subject** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

5. **Think it is important to understand the work in mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

6. **Are asked more questions by the mathematics teacher** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

7. **Give up when they find a mathematics problem is too difficult** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

8. **Have to work hard in mathematics to do well** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

9. **Enjoy mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

10. **Care about doing well in mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

11. **Think they did not work hard enough if do not do well in maths** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

12. **Parents would be disappointed if they do not do well in maths** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

13. **Need maths to maximise future employment opportunities** *

Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

14. **Like challenging mathematics problems** *

Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

15. **Are encouraged to do well by the mathematics teacher** *

Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

16. **Mathematics teachers thinks they will do well** *

Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

17. **Think mathematics will be important in their adult life** *

Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

18. **Expect to do well in mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

19. **Distract other students from their mathematics work** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

20. **Get the wrong answers in mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

21. **Find mathematics easy** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

22. **Parents think it is important for them to study mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

23. **Need more help in mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

24. **Tease boys if they are good at mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

25. **Worry if they do not do well in mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

26. **Are not good at mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

27. **Like using computers to work on mathematics problems** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

28. **Mathematics teachers spend more time with them** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

29. **Consider mathematics to be boring** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

30. **Find mathematics difficult** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

31. **Get on with their work in class** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

32. **Think mathematics is interesting** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

33. **Tease girls if they are good at mathematics** *
Mark only one oval.

- Boys definitely
- Boys probably
- No difference
- Girls probably
- Girls definitely

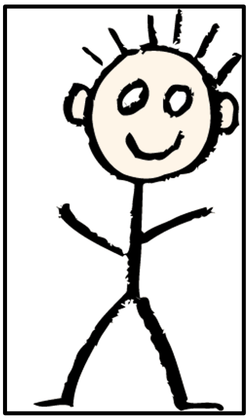
34. **Would you be interested in participating further in an interview at a time convenient to you? If yes, please include your e-mail address for correspondence.** *

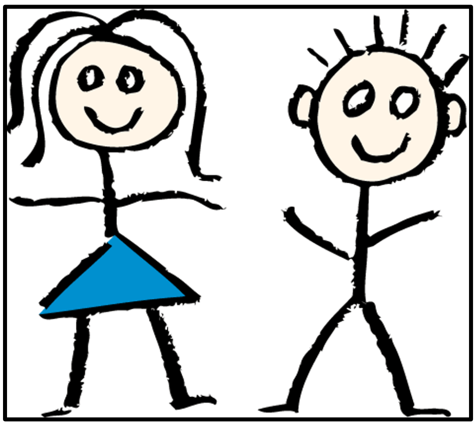
____
____
____
____
____

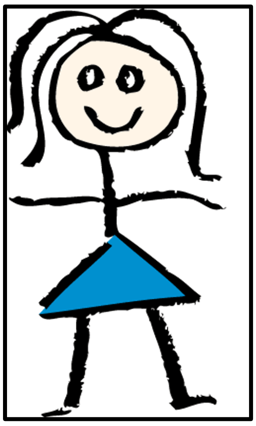
Appendix E: Student Interview Questions

1. Maths/ Counting and adding is their favourite subject . . . B/G/ND
2. Which one will give up when they find a counting problem that is too hard? . . . B/G/ND
3. Which one will have to work hard at counting and numbers to get it right? . . . B/G/ND
4. Which one would enjoy maths the most? . . . B/G/ND
5. Which one would care the most about doing well in maths? . . . B/G/ND
6. Which one's parents would be sad or disappointed if they didn't do well in maths? . . . B/G/ND
7. Which one needs maths when they grow up and get a job? . . . B/G/ND
8. Which one likes it when maths and counting gets a little harder? . . . B/G/ND
9. Which one thinks maths will be important when they're grownups? . . . B/G/ND
10. Which one expects that they will do well at maths? . . . B/G/ND
11. Which one gets the answers wrong in maths? . . . B/G/ND
12. Which one finds maths easy? . . . B/G/ND
13. Which one do you think will need more help in maths? . . . B/G/ND
14. Which one do you think will get worried if they're not good at maths? . . . B/G/ND
15. Which one isn't good at maths? . . . B/G/ND
16. Which one likes using computers to do maths? . . . B/G/ND
17. Which one thinks maths is boring? . . . B/G/ND
18. Which one finds maths hard? . . . B/G/ND
19. Which one thinks maths is interesting? . . . B/G/ND
20. Which one will tease other kids if they're not good at maths? . . . B/G/ND

Appendix F: Gender Cards for Student Interview







Appendix G: Parent Semi-Structured Interview

<u>Questions for parents</u>

1. Ask for permission to interview their child if haven't already.
2. How many children do you have other than _____? Age and gender. What has their maths experience been like? (if they are school age)
3. Would you consider yourself good at maths? Why? How do you measure this?
4. Do you use maths day-to-day?
5. Maths simile e.g. maths is like a jigsaw puzzle, tricky but satisfying when a piece fits. Maths is like stepping on lego – painful! Maths is like riding a bike, you have to learn how to do it but then it's so much fun.
6. Maths anxiety scale question

$$9-3\div\frac{1}{3}+1=$$

7. Are you happy with where your responses are sitting? Time to change…
8. Reflect on individual responses
9. When you were responding - were you thinking about your personal experiences with maths/ your other children or maths in general? Media etc.
10. Think back to an important moment in your maths learning and tell me that story? Why is it significant? Is it representative of your overall experience with maths?
11. Do you think children are born with the capacity to be good at maths or not? i.e. to have a 'maths brain' or a 'language brain'? Or is it all learned?
12. What are your hopes for your kindergarten child in life? School/ Career.
13. Do you expect that they should persevere in maths in later years as it gets more challenging? What if they're finding it very difficult and it is causing them distress? Select maths for Year 11 and 12? Go into a profession that uses maths?

14. Maths in 2017 HSC – why do you think?

Course name	Male %	Female %
Maths General 1	62%	38%
Maths General 2	49%	51%
Maths	54%	46%
Extension 1	60%	40%
Extension 2	64%	36%

15. Scenario: Your child has come home from school very upset because they don't understand a concept in maths. What do you say to them?

Appendix H: Content Analysis Showing Frequency of Parents' Responses