STEM Subject Choice: Factors that influence the decisions of Australian students entering Year 12

by

David Anthony Jeffries

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Contents

FIGURES

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ABSTRACT

An advancing global economy and rapidly developing digital technologies signal the necessity to develop citizens who are adequately equipped with science, technology, engineering and mathematics (STEM) skills and the associated abilities to think critically and creatively for solving problems effectively. Claims of STEM skills shortages in many Western countries (including Australia) are coupled with a desire to enhance STEM capabilities of citizens to boost economic productivity. Worryingly, there is a decline in STEM subject enrolment in senior secondary school and university in recent decades.

This study builds on previous research that has identified individual characteristics such as gender, SES, ethnicity, career aspirations, and the influences of peers and teachers on STEM educational decisions. School level factors, such as average school SES and gender balance, have also been considered.

Little research was found (in the researcher's context of South Australia) that addressed STEM as a whole subject choice in Year 12, where STEM as a whole refers to the collection of subjects from curriculum areas of science, technology, engineering and mathematics. More specifically, the suite of subjects categorised as STEM as a whole include high-level mathematics, science, engineering and digital/information technology subjects. A detailed description is provided in Section 3.4.3.1.1. In order to address this gap, a mixed methods study investigating factors that influence students' STEM subject enrolment choices was undertaken. This study used quantitative data from Australian samples of students who participated in the Programme for International Student Assessment (PISA) and the Longitudinal Surveys of Australian Youth (LSAY). These analyses were followed by a qualitative study of the enrolment decisions of a different sample of senior secondary students in South Australia.

The theory of planned behaviour (TPB) was the guiding conceptual framework for the collection, analysis and interpretation of data. This research was approached with a pragmatist worldview, highlighting the need to attend to the quantitative phase of the research with a post-positivist lens, and the qualitative phase of the research with an interpretivist lens.

In the quantitative phase, a combination of single-level and multilevel multiple regression and structural equation models identified factors that influence students' decisions about enrolling in a STEM subject in Year 12. Gender and immigrant status were shown to influence STEM enrolment decisions, but they were mediated by variables including attitudes towards science and achievement in science and mathematics. School level factors such as location, ratio of females, ratio of native (at least one parent born in Australia) students and average school SES seemed to moderate the student-level relationships. The qualitative phase used interview data from 20 participants. Factors such as attitudes towards STEM, perceived norms, perceived behavioural control, and other background factors influenced STEM enrolment decisions.

The majority of findings from both phases of the study are consistent with prior research findings. However, some add to the literature e.g. the differences in STEM enrolment patterns between native students and those from migrant backgrounds, while others suggest the need for further research. A synthesis of the findings provides a more nuanced account of the complex phenomena investigated in this research and helps to explain how students might navigate the STEM subject decision-making process entering Year 12. It is suggested that the TPB be expanded to accommodate multilevel or nested data. Research findings presented in this thesis have implications for students and their families along with teachers and leaders within schools. A greater understanding of how decisions are made to enrol in STEM subjects in Year 12 will enable all stakeholders to have more effective discussions, resulting in students following more considered and appropriate pathways into post school education and careers in STEM and in turn meeting the economic and social needs of our rapidly changing society.

DECLARATION

I certify that this thesis:

1. does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and
2. to the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Signed 

David Anthony Jeffries

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Some content from Chapters 2, 3, 4, 6 and 7 has been published in the peer reviewed *International Journal of Science and Mathematics Education* (IJSME):

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Content from the published article's 'Introduction' is dispersed throughout Chapter 2. Content from the 'Conceptual Framework' section is reproduced in Chapter 2. Content from the 'Secondary Data', 'Data Preparation', 'Model Estimation', 'Model Building', and 'Model Validation' sections are dispersed throughout Chapter 3. Content from the 'Results' section are dispersed or reproduced throughout Chapter 4. Content from the 'Discussion', 'Limitations' and 'Conclusion' sections are dispersed throughout Chapters 2, 6 and 7. The co-authors of this publication can be attributed with approximately 10% of this publication output. They were predominantly involved in the conceptualisation, design, interpretation and drafting phases of the research.

The views presented throughout this thesis do not necessarily reflect those of the Australian Government, participants from the 2006 Australian cohort of the Programme for International and Student Assessment (PISA) and Longitudinal Surveys of Australian Youth (LSAY), or students from South Australian Department for Education (DfE) and Independent (AISSA) schools.

1. INTRODUCTION

1.1. Focus of the research

The purpose of this thesis is to contribute to the understanding of how Australian students in the senior secondary phase of schooling (Years 11 and 12) make educational decisions. More specifically, it aims to further the understanding of what underlies the decision-making process of students when deciding whether to enrol in a science, technology, engineering and mathematics (STEM) subject in Year 12. In order to unpack how students navigate the decision-making process entering Year 12, an exploration of the range of factors that may influence the decision-making process is needed. A range of factors including those related to individuals, families, schools and society as a whole are explored. Once potentially influential factors are identified an investigation into the relationships between them and how their interaction ultimately affects the likelihood of enrolment in a STEM subject in Year 12 is undertaken. Considering the complexity of the decision-making process students undergo in this period of their lives, a greater understanding of the relationships between influential factors is used to explicate the underlying decision-making process.

1.2. The research problem

In reviewing national and international literature on the current state of STEM education and workforce demands, a STEM worker and STEM skills deficit is identified. Various reports have outlined the continuing decline in senior secondary students' enrolment in STEM subjects over the last few decades (Ainley, Kos, & Nicholas, 2008; Ainley & Ainley, 2011; Australian Industry Group, 2015; Kennedy, Lyons & Quinn, 2014; Roberts, 2013; Smyth & Hannan, 2006). This trend is also apparent at the tertiary level with students unwilling to enrol in STEM degrees (National Science Board, 2004; Office of the Chief Scientist, 2012). In the US (National Academies of Sciences Engineering and Medicine, 2016b), UK (Parliamentary Office of Science and Technology, 2013; Royal Academy of Engineering, 2012), and Australia (Australian Industry Group, 2015), there was a reported shortage of adequately trained STEM workers to contribute to an advancing technological society. Although several researchers have questioned the validity of these STEM worker shortages

(Lowell & Salzman, 2007; Panizzon, Corrigan, Forgasz, & Hopkins, 2015; Salzman, Kuehn, & Lowell, 2013; Stevenson, 2014), developing adequate numbers of school and higher education graduates who are equipped with high level STEM skills, is necessary to manage the evolving digital and global economy (Department of Further Education Employment Science and Technology, 2011, 2014). STEM skills are defined as those skills that are developed as a result of attaining a university level degree in science, technology, engineering and mathematics (EU Skills Panorama, 2014). Skills such as being numerate, able to critically analyse, scientific and mathematical reasoning, problem solving, communicate scientifically, and transferring theoretical ideas into practical solutions (United Kingdom Commission for Employment and Skills, 2011) Beyond the reported shortage of STEM workers, the value of people possessing STEM skills and the flow-on effect to economic productivity has been projected (Deloitte, 2012; Lee, 2011; Productivity Commission, 2016). Increasing the number of citizens who are mathematically and scientifically literate was predicted to address the demands of a changing global economy (Clyne, 2014) and promote innovative practices and economic growth (Engineers Australia, 2007). In Australia, encouraging students to continue to develop high level STEM skills, along with associated critical and creative thinking skills, through all levels of education from pre-primary to tertiary, would likely equip them with the ability to make informed decisions impacting society (Engineers Australia, 2007; Office of the Chief Scientist, 2013).

In Australia, many policy initiatives and research reports have been implemented by various private and public agencies to address the workforce and societal demands to increase the number of citizens with STEM related skills and associated problem-solving skills such as critical and creative thinking. State and national government departments have released several policy documents pertaining to raising the state of STEM education, particularly since the release of the Melbourne Declaration on Educational Goals for Young Australians (MDEGYA) (Ministerial Council on Education Employment Training and Youth Affairs, 2008). The most targeted response to the MDEGYA in relation to STEM education was the national STEM school education strategy 2016 – 2026 (Education Council, 2015). Along with this a National Innovation and Science Agenda (NISA) report was released (Commonwealth of Australia, 2015) outlining a commitment of $1.1 billion in expenditure to improve areas of need. Also, research reports were produced and disseminated by the Australian Curriculum, Assessment and Reporting Authority (ACARA) (2016) and the Australian Industry Group (AiG) (2015) providing recommendations and resources to help strengthen the relationships between stakeholders at all levels of education. In South Australia, a STEM learning strategy (2017-2020) was produced that offered recommendations and an investment of $250 million for infrastructure and resources (Department for Education and Childhood Development, 2016).

A series of attitudinal constructs related to STEM have been identified as potentially influential over students' decisions to participate in STEM education. A student's level of interest (Ainley et al., 2008; Köller, Baumert, & Schnabel, 2001), enjoyment (Sheldrake, Mujtaba, & Reiss, 2015; Vidal Rodeiro, 2007), motivation (Sheldrake et al., 2015), perception of the difficult nature (Abraham & Barker, 2014; Potvin & Hasni, 2014), self-efficacy (Abraham & Barker, 2014; Lee, 2011; Sahin, Ekmekci, & Waxman, 2017), self-concept (Potvin & Hasni, 2014; Sheldrake et al., 2015), perception of the value (Else-Quest, Mineo, & Higgins, 2013), perception of the relevance (Abraham & Barker, 2014; Kennedy, Quinn, & Lyons, 2018), and anxiety (Clyne, 2014) in/of STEM have been shown to influence achievement, aspirations and enrolment in STEM subjects at various levels of education.

The influence of 'others', such as classroom teachers, peers, parents and society, on students' educational decisions has been investigated by many international researchers. Classroom teachers of Junior Science have been shown to influence the likelihood of students continuing to follow a pathway into STEM in Year 12 (Lyons & Quinn, 2010). They also found that peers are likely to be influential over the decision-making process of students entering Year 12. The formation of stereotypical images of and perceptions of scientists has been shown to be influenced by peers, parents and society as a whole (Ainley et al., 2008; Clyne, 2014; Engineers Australia, 2007; Henriksen, Dillon, & Ryder, 2015; Lyons & Quinn, 2010). These stereotypes can result in the perception that studying STEM is being 'nerdy' or 'geeky' (DeWitt, Archer, & Osborne, 2013) and students often apply coping strategies to overcome this stigma (Forgasz, 1994). Parental aspirations for their children were shown to influence their children's aspirations for a STEM related career (Lloyd, Gore, Holmes, Smith, & Fray, 2018).

Previous research in the UK has investigated students' lack of control over their enrolment decisions due to the 'streaming' practices of schools in the high school years leading up to Year 12 (Archer, Moote, Francis, DeWitt, & Yeomans, 2017). Archer et al. (2017) found that stratification in Year 10 science made lower performing students feel that they were being discouraged from higher level science classes, resulting in them not choosing to pursue these pathways into Years 11 and 12. Australian research by Hogan and Down (2015) also found that streaming practices (academic vs non-academic pathways) in early high school resulted in the disengagement of many students from high level STEM subjects in Year 12.

A variety of background factors has been shown to influence students' STEM career aspirations and subsequent educational decisions at various levels of education. The gender of students has often been reported as impacting the likelihood of their engagement with STEM education, with the underrepresentation of females in post-compulsory STEM education and STEM careers (United Nations Educational Scientific and Cultural Organization, 2017). The socio-economic status of students (Fullarton & Ainley, 2000; Vidal Rodeiro, 2007) and regions in which schools are situated (McGaw, 2006; Perry & Southwell, 2014) have been shown to influence the likelihood of students engaging in STEM education. The ethnicity and immigrant status of students have previously been argued to affect their decision-making process when deciding whether to continue with STEM beyond the compulsory stages of schooling (Else-Quest et al., 2013; Fullarton & Ainley, 2000; Sahin et al., 2017; Saw, Chang, & Chan, 2018; Vidal Rodeiro, 2007). The educational level (Smyth & Hannan, 2006) and occupation (Croll, 2008; Sikora & Pokropek, 2012b) of parents have previously been shown to impact students' STEM education decisions.

Many school related factors have also been shown to influence students' attitudes towards subject areas and their subsequent enrolment decisions. Students also tend to enrol in subjects and have educational aspirations that are consistent with their peers (Gemici, Bednarz, Karmel, & Lim, 2014; Wang & Degol, 2013). The "big-fish-little-pond" effect is often used to explain peer effects on students' enrolment patterns (Marsh, Trautwein, Lüdtke, & Köller, 2008; Nagengast & Marsh, 2012). Students' post school aspirations and the associated higher education requirements (ATAR scores and course pre-requisites) likely influence the STEM related decisions going into senior secondary schooling (Atweh, Taylor, & Singh, 2005; Bøe, Henriksen, Lyons, & Schreiner, 2011). Students make relative judgements about the value of subjects based on their ATAR scaling tendencies and perceived difficulty (Hine, 2018; Pitt, 2015). Prior achievement in STEM subjects ultimately influences students' attitudes towards and subsequent enrolment in STEM subjects in senior secondary school and STEM majors at university (Ainley et al., 2008; Fullarton & Ainley, 2000; Lee, 2011; Vidal Rodeiro, 2007). A student's perception of the quality of their STEM teachers based on previous experience related to in-class activities, support and reputation, has been shown to be influential (Atweh et al., 2005; Bennett & Hogarth, 2009; De Loof, Struyf, Boeve-de Pauw, & Van Petegem, 2017). School sector (Fullarton & Ainley, 2000; Fullarton, Walker, Ainley, & Hillman, 2003), school gender (Sikora, 2014a), school size (Spielhofer, O'Donnell, Benton, Schagen, & Schagen, 2002), and subject offerings (Legewie & DiPrete, 2014; Smyth & Hannan, 2006) have all been shown to influence students' attitudes towards, aspirations for and enrolment in STEM education at various levels. Added exposure to STEM experiences outside of the classroom (National Research Council, 2015), including at home (Ho, 2010), can improve students' attitudes towards and aspirations for a STEM career.

Much of the debate for advancing STEM education using a skills-based argument has focussed on the development of 21st century skills and critical and creative thinking skills. This thesis does not address these skills often associated with STEM explicitly, instead focussing solely on enrolment in STEM subjects in Year 12. In relation to STEM education, a plethora of research has been conducted in order to investigate the educational decisions of students at various stages (Archer et al., 2017; Fullarton & Ainley, 2000; Lyons & Quinn, 2010). However, very few have focussed on STEM as a whole, focussing instead on individual STEM subjects. Adding to the complexity of summarising findings from the literature is the variety of definitions and categorisations of STEM that have been used, resulting in the lack of a commonly accepted delineation of what constitutes a STEM subject. In this research, subjects classified as 'STEM' are those that are likely to lead to a STEM university pathway based on definitions used by previous researchers and the author's own predefined criteria. The suite of subjects categorised as STEM include high-level mathematics, science, engineering and digital/information technology subjects. A more detailed description is provided in Section 3.4.3.1.1. More specifically, no research has been found that focusses on STEM as a whole subject choice in Year 12 within the South Australian context. Students in Australia typically have the option to start choosing the subjects they wish to enrol in as they enter Year 11, making the end of Year 10 the obvious choice for examining STEM subject choice. However, in South Australia, mathematics is compulsory in Year 11, making it difficult to examine the variation in STEM subject choice at or before this point (see Section 3.8). The complexity of the STEM decision-making process of students entering Year 12 requires a more in-depth investigation with a mixed methods approach. The ability to address research questions using both quantitative and qualitative data, allows the researcher to gain a more nuanced understanding of what underlies the STEM decision-making process of students (Rowan-Kenyon, Swan, & Creager, 2012; Tytler & Osborne, 2012). More specifically, the quantitative phase of the research attempts to explicate the factors that influence the enrolment decisions of students entering Year 12, whilst the qualitative phase attempts gain an understanding of the underlying decision-making process that students may navigate during this time.

1.3. Significance of the research

Prior to undertaking this research, I was a senior secondary mathematics and physics teacher at a public school in rural South Australia. My experiences in the classroom included numerous discussions with students and their parents about their aspirations and subsequent reasons for deciding whether to enrol in STEM subjects in Year 12, which sparked a curiosity that led to this research. I noticed that many students had no clearly defined aspirations, a simplified understanding of the factors that influenced those aspirations, and a lack of knowledge of the steps that needed to be taken in order to follow the most appropriate pathway.

A student’s navigation through the complex factors that underlie the decision-making process justifies research that investigates how these various factors interrelate and that helps to explain this process. Findings reported in this thesis (Chapter 4 and Chapter 5) outline a number of student and school level factors that influence students’ attitudes towards, achievement and subsequent enrolment in STEM subjects in Year 12. It is clear from the discussion provided in Chapter 6 that the interconnecting relationships between these various factors provides a complex picture and they are expected to have implications for students, parents, teachers and schools. A greater understanding of the decision- making process that students undergo when deciding whether to enrol in STEM subjects in Year 12 would allow stakeholders to address this important issue.

1.4. Outline of the thesis

An outline of the thesis structure is provided to allow the reader to gain an overview of the research agenda and how the problem is addressed.

Chapter 1 outlines the focus of the research including the general aim of the study, how it is expected to contribute to an understanding of the phenomenon, and the specific objectives related to the phenomenon that are addressed. The research problem is highlighted based on a review of the literature and issues relating to a purported STEM skills shortage, the necessity of developing STEM literate citizens, and STEM policy initiatives that have been implemented over the last decade. A summary of the approaches and findings of other researchers is described. STEM career aspirations, attitudes towards STEM, influence of others (peers, parents and teachers), control over decisions, and various background factors (including gender, SES, ethnicity, parental education and occupation, prior achievement, teacher quality, school context, and exposure to STEM outside of the classroom) are discussed. The identified gap in the research is outlined. A justification for the current research investigating STEM subject choice as a whole and adopting a mixed methods inquiry is proposed. Following this, my personal background and motivation for investigating this problem is outlined along with the significance of the research findings for various stakeholders including students, parents, teachers and schools.

Chapter 2 reviews literature relating to STEM and the workforce, including the reported STEM skills shortage in many Western countries, the necessity for developing STEM literate citizens for the technologically advanced and global economy, and policy initiatives and research reports relating to STEM education by various government and private organisations. Following this, theories of behaviour and choice are outlined, with a justification for the theory of planned behaviour (TPB) being chosen as the guiding conceptual framework for the remainder of the literature review, research methods, analyses and interpretation of findings. Various factors that have previously been shown to influence the STEM educational decision-making process at various levels of education are then highlighted. These factors include intentions to enrol in STEM (STEM career aspirations), attitudes towards STEM (including interest, enjoyment, motivation, perceived difficulty, self-efficacy, self-concept, value and relevance, and anxiety), perceived norms (influenced by significant others), perceived behavioural control, and various background factors. Previous research relating to demographic background (gender, SES and ethnicity/immigrant status), parental education and occupation, peer enrolment and achievement, ATAR requirements and university pre-requisites, school context, prior achievement, teacher quality and exposure to STEM outside of the classroom is discussed. Gaps in the research and subsequent research questions that drive the investigation are outlined in the concluding stages of the chapter.

Chapter 3 provides an overview of the research methodology that was developed for the current investigation into STEM subject choice in Year 12. A justification for adopting a pragmatist worldview is provided along with the necessity of using a mixed methods approach to address a multifaceted and complex phenomenon. Further, a justification for approaching the quantitative phase of the research with a post-positivist lens and the qualitative phase of the research with an interpretivist lens is outlined. The research methods for both the quantitative and qualitative phases of the research including data questions, data collection procedures and data analyses techniques are described. A series of ethical considerations, limitations and delimitations are also outlined.

Chapter 4 focusses on the results of the quantitative phase of the research. It outlines how descriptive statistics, multiple regression modelling and structural equation modelling (including both single and multilevel analyses) are used to address Research Question 1. Single level models are developed to account for the influence of and interaction between student level variables (gender, SES, immigrant status, enjoyment of science, personal value of science, self-concept in science, and achievement in science and mathematics) on STEM subject choice in Year 12. Multilevel models are developed to extend student level models to include the moderating effects of school level variables (location, ratio of immigrant students, ratio of female students and average school SES) on the relationship between demographics variables and the subject choice outcome. A synthesis of the results allows the reader to gain an overview of the various results and how they are combined to address Research Question 1.

Chapter 5 outlines the findings of the qualitative phase of the research. A profile of the students (gender, country/region of birth, parental country/region of birth, parental education and occupation, and STEM subject choice in Year 11 and Year 12) and schools (sector, location, SES, size and gender) involved in the qualitative phase of the research (South Australia only) are outlined. Interview responses were audio recorded, transcribed, coded and themes developed to address Research Question 2. Intention to enrol in STEM (response to the question "Going in to your subject selection meeting, did you select the subjects for Year 12 that you originally intended to?") is discussed. Students' attitudes towards STEM including enjoyment, interest and motivation, self-efficacy, self-concept, nature of STEM, rewards of STEM, perceived difficulty, personal value and societal value of STEM are highlighted. Themes that address students' perceived norms and the influence of parents, teachers and peers are outlined. The perceived behavioural control that students have over the decision is addressed using responses to the question "Do you feel that the decision to enrol/not enrol in a STEM subject(s) was entirely your decision?" A variety of background factors and their influence over the decision-making process, including education and career aspirations, gendered construction of identity and affinity with STEM, personality traits, parental education and occupation, school context, prior achievement, teacher quality, and exposure to STEM outside of the classroom, are highlighted.

Chapter 6 provides a discussion of the findings and how they compare to previous research findings highlighted in the literature review. A combination of consistent, contrasting and novel findings are outlined. A short discussion on the value of the TPB as the guiding conceptual framework is presented along with an argument for its consideration as a multilevel model for use with nested data. Eight key factors that have a series of interrelating relationships with other student and school level factors of influence are discussed in detail. These are gender, SES, immigrant status, the intersection of demographic background characteristics, education and career aspirations, the value students place on STEM, prior experience in STEM classrooms and the level of actual control students have over their enrolment decisions.

Chapter 7 summarises the major components of the research including the research questions, methods of data collection and analyses, and major findings from both phases of the research. Major findings relating to disparity in enrolment based on demographic background (gender, SES and immigrant status), attitudinal constructs, achievement in STEM, perceived norms, educational and career aspirations for STEM, and various school related factors are shown to influence the decision-making process of students entering Year 12. Implications of the findings for students and their families, teachers and schools are outlined. Various limitations of these findings are considered followed by concluding remarks.

2. LITERATURE REVIEW

2.1. Introduction

The review of the literature outlines research on national and international trends in STEM education and employment in recent decades. A summary of the STEM related workforce demands and economic concerns of a STEM skills deficit is outlined. Policy documents pertaining to the increasing demand to develop STEM literate citizens and implications for the education system internationally, nationally and locally are also outlined. Alternative theories of educational choice are discussed, with the theory of planned behaviour (TPB), chosen as the conceptual framework guiding the study, described in detail. Various factors within the literature related to educational choice are highlighted as they relate to the constructs within the TPB, namely intention, attitudes, perceived norms, perceived behavioural control and background factors. Gaps found within the research literature provide evidence for needing to better understand STEM subject choice and the factors that may influence students' enrolment decisions.

2.2. STEM and the workforce

International and national literature on STEM education and workforce demands have highlighted two themes as important areas to address, namely the STEM worker shortage and the STEM skills shortage.

2.2.1. STEM worker shortage

In recent decades, the number of students enrolling in STEM subjects in senior secondary school and STEM majors at university has declined worldwide (Ainley & Ainley, 2011; Roberts, 2013; Smyth & Hannan, 2006). This has often been referred to as the leaky STEM pipeline (Tytler, Osborne, Williams, Tytler, & Clark, 2008; Watt, 2016), where primary school students engaged in STEM learning would remain engaged throughout their high school years, into tertiary education, and finally into STEM related careers.

In the US, the National Science Board (2004) suggested that there is a declining number of citizens willing to undertake science and engineering degrees. This is of particular concern considering the projected increased need for STEM graduates in the future workforce (Heaverlo, 2011; Henriksen et al., 2015). The US National Academies of Sciences, Engineering, and Medicine (2016b) indicated that the "United States will need approximately one million more STEM professionals, relative to the number that it is currently producing, if the nation is to retain its international competitiveness in science and technology and meet these workforce demands" (2016b, p. 1). In the UK, the Royal Academy of Engineering (2012) projected a STEM worker shortage from 2012 to 2020, reporting a shortfall of 10,000 STEM graduates each year. A review of the state of STEM education for 14-19 year olds in the UK was undertaken by the Parliamentary Office of Science and Technology (2013), highlighting a number of concerning issues. There was a STEM worker shortage with employer hiring difficulties noted, producing a gap between supply and demand in the workforce (Parliamentary Office of Science and Technology, 2013). This issue was attributed to declining educational standards and a shortage of adequately trained teachers. It was also found that a student's attitude towards STEM does not always translate to STEM career aspirations, and strategies typically used to overcome this have not always worked (Parliamentary Office of Science and Technology, 2013).

There are conflicting reports about the validity of claims of a STEM worker shortage. A report by Salzman, Kuehn and Lowell (2013) stated that "the United States has more than a sufficient supply of workers available to work in STEM occupations" (Salzman et al., 2013, p. 2), with only half of US STEM graduates being recruited into a STEM occupation. Lowell and Salzman (2007) argued that supposed STEM worker shortages in the US were anecdotal and lacked evidence. The anecdotal reports were primarily employer or industry hiring experiences, which could be influenced by a range of factors and be counterproductive, if assumed to be linked to shortages (Lowell & Salzman, 2007). In the UK, several supply and demand calculations suggested no shortage (Bosworth, Lyonette, Wilson, Bayliss, & Fathers, 2013). That report goes on to suggest that it appears to be "more about lack of suitably qualified candidates rather than a numerical shortage of STEM degree holders" (Bosworth et al., 2013, p. 71). Smith (2010) claimed that the reported 'swing' away from science enrolment in undergraduate degrees in the UK was false, with the sciences "retain[ing] their share of the undergraduate population during a period in which the sector has expanded rapidly" (p. 281). However, the number and percentage of enrolments stratified by area suggested that the landscape of science education at university had changed from 1993 to 2009, where:

> there have been shifts in popularity towards more applied subjects, such as psychology and environmental science, and away from the 'traditional' sciences, such as physics, chemistry and biology, whose numbers have not kept pace with the increase in other fields (Smith, 2010, p. 294)

In contrast, Panizzon, Corrigan, Forgasz and Hopkins (2015) argued that "the rhetoric from governments about continuing falling rates of [STEM] participation in the senior secondary sector is not substantiated when scrutinized using recent national or state data" (2015, p. 71). They argue that there is no common delineation of STEM across the breadth of research worldwide; subjects included in STEM at both secondary school and university level are not uniform across reports; and current data are not being used appropriately and asserted that unless:

> the specific areas of need are clearly communicated to the populace and stakeholders, the government and industry rhetoric that there is a shortage across the board does little to address any 'real' gaps that very likely exist in the STEM workforce (Panizzon et al., 2015, p. 73).

While a substantial volume of literature asserts STEM worker shortages and declining participation in STEM subjects and courses, there is little hard evidence of this. If a worker shortage truly was present in Australia, almost all STEM graduates would find work in their respective fields and be earning high graduate salaries. However, it is not clear that this situation pertains. As can be seen in Table 2-1, the proportion of STEM graduates gaining full-time employment has been steadily declining in most fields since 1982.

Table 2-1

Selected STEM degree graduates working full-time as a proportion of those available for full-time employment, 1982-2014 (%)

Subject	Year								
	1982	1986	1990	1994	1998	2002	2006	2010	2014
Physical Sciences	77.6	83.5	79.5	51.4	71.7	59.8	73.3	76.9	54.9
Chemistry	78.3	89.8	82.9	74.9	69.8	77.0	83.7	68.8	57.1
Life Sciences	73.7	80.5	79.3	58.6	62.0	69.6	74.2	61.0	48.0
Geology	87.0	87.0	77.5	72.3	77.2	75.3	87.7	72.9	56.9
Computer Sciences	92.5	95.2	92.4	71.9	84.7	70.5	78.8	73.3	67.2
Chemical Engineering	91.6	91.9	95.6	80.0	75.0	89.2	83.2	67.7	61.6
Civil Engineering	94.8	92.0	94.6	84.0	88.3	91.1	95.4	92.5	74.9
Electrical Engineering	95.2	95.5	94.1	78.1	88.4	83.3	92.0	76.9	78.0
Mechanical Engineering	95.0	93.0	92.7	78.2	86.5	81.5	89.9	80.5	71.0
Mining Engineering	90.7	90.1	100.0	93.4	93.8	90.9	100.0	90.5	82.8
Mathematics	86.7	89.6	85.7	59.3	73.9	72.6	85.7	66.8	64.9

Source: Adapted from Table 5 in Graduate Careers Australia (2015, pp. 16-17).

Employment rates in some STEM fields like civil and mining engineering have remained relatively steady through the 1980s and 1990s but have shown a sharp decline since 2010. The 2014 figures (in the table above) for all STEM fields are significantly below the average over the 30 year time period. However, it must be acknowledged that these data refer to graduates in work about 4 months after graduation and do not indicate whether they are working in the field associated with their degree. Norton and Cakitaki (2016) analysed data from the Household, Income and Labour Dynamics (HILDA) survey and provided a worrying picture for science graduates. Within the fields of STEM, science enrolment is the largest, and yet:

> Science bachelor degree graduates generally have worse employment outcomes than graduates in most other disciplines: fewer find full time jobs when they graduate, fewer have full time jobs three years after graduation, and fewer use what they learnt in their job (Norton & Cakitaki, 2016, p. 84)

However, employment statistics are based on those seeking full-time employment following graduation from bachelor degrees in science, while in reality almost half of each cohort continues studying full-time (honours/postgraduate degrees or other undergraduate degrees) (Norton & Cakitaki, 2016). These values are skewed as many students undertaking undergraduate science degrees use them as a pathway into medicine (Norton & Cakitaki, 2016). Higher levels of funding for postgraduate research projects also add to the likelihood of bachelor level graduates continuing into postgraduate study (Norton & Cakitaki, 2016).

Xu (2017) found that people not utilising their STEM degrees by moving into congruent STEM career fields were affected by attitudes towards career outcomes, including perceived earnings and job satisfaction. Still, the study concluded that STEM graduates had better employment prospects than non-STEM graduates, with lower rates of unemployment after graduation (Xu, 2017). Therefore, it is an inherent responsibility of researchers to take a more critical look at the current state of STEM in Australia and direct research towards the most beneficial areas for economic growth and citizen prosperity. Although the importance placed on STEM education has traditionally been for the development of citizens' STEM specific skills and economic outcomes, we are reminded that:

> STEM education in its ideal form addresses more than simply academic and economic outcomes. Personal, social and economic development all require more than STEM knowledge and skills. There is an understanding that STEM education should help students develop a set of personal attributes that are variously known in the education sector as 21st century skills, soft skills or general capabilities. To employers these are also known as employability skills, and include competencies such as problem solving, collaboration, creativity and innovation (Timms et al., 2018, p. 2).

Although these generic skills are able to be developed through STEM education, it is not the only path for students to develop them.

Confusion surrounding the validity of claims of a STEM worker shortage may relate to the fact that there is no agreed definition of what constitutes a STEM subject or course. Siekmann (2016) explored the literature associated with the development of the term STEM and reasons for the varying definitions that have followed. Use of the term can be traced back to the late 1990s and it evolved through the years, being used commonly in the fields of government, industry and education (Siekmann, 2016). In another report, Siekmann and Korbel (2016) described how the term STEM was commonly used in the US from 1996 onwards, whereas the acronym SET (science, engineering and technology) was used in Australia until 2006. Since then, "STEM has evolved into a bewildering number of concepts and variants, for example, 'S.T.E.M.', 'STEAM' or 'STEMM'" (Siekmann & Korbel, 2016, p. 11), with the inclusion of the arts or medicine depending on the definition preferred. One of the main reasons for such confusion around the definition of what constitutes STEM skills is that they are "problematic to define as they do not exist in isolation; similar to innovation skills they are guiding, enabling or facilitating skills and borrow content from other skills groups" (Siekmann & Korbel, 2016, p. 6). Following an outline of a number of concerning issues relating to the varying nature of STEM and definitions that ensued, Siekmann (2016) attempted to elucidate the concept of STEM and its application in education, explaining that STEM is an acronym for "the disciplines of science, technology, engineering and mathematics taught and applied either in a traditional and discipline-specific manner or through a multidisciplinary, interconnected and integrative approach" (Siekmann, 2016, p. 3). The focus is on solving real-world problems using technical and scientific approaches through the development of critical and creative thinking skills (Siekmann, 2016). Siekmann (2016) suggested that if this approach is taken from primary through tertiary education, it will improve the skills of teachers, scientists, engineers and digital specialists, whilst producing scientifically and technologically literate citizens entering a range of careers.

2.2.2. STEM skills shortage

In Australia, there has been a continuing decline in science enrolment numbers in senior secondary schools (Abraham, 2011; Ainley et al., 2008; Ainley & Ainley, 2011; Australian Industry Group, 2015; Engineers Australia, 2007; Lyons & Quinn, 2010; Office of the Chief Scientist, 2012; Panizzon & Westwell, 2007). From the year 1991 to 2007, the number of Year 12 students across Australia that enrolled in traditional science subjects (physics, chemistry and biology) decreased (Ainley et al., 2008). Physics enrolment numbers decreased from 38,260 (20.9%) to 28,931 (14.6%), chemistry fell from 42,645 (23.3%) to 35,697 (18.0%), and biology enrolment dropped from 65,852 (35.9%) to 48,964 (24.7%) (Ainley et al., 2008). A similar trend was identified for mathematics (Ainley et al., 2008; Ainley & Ainley, 2011; Australian Industry Group, 2015; Clyne, 2014; Engineers Australia, 2007; Panizzon & Westwell, 2007), with enrolment in advanced mathematics falling from 14.2%

(1995) to 9.6% (2015) whilst intermediate mathematics fell from 27.3% to 19.2% in that time (Barrington & Brown, 2014; Barrington & Evans, 2016). Enrolment numbers in information technology subjects also declined in the years 1995-2007, falling from 31,353 (18.2%) to 28,668 (14.5%) with a peak during this period in 2001 with enrolments of 47,464 (25.2%), highlighting the sharp decline from 2001 to 2007 (Ainley et al., 2008). It was reported that the ratio of STEM to non-STEM university graduates in Australia had fallen from 22.2% in 2002 to 18.8% in 2010 (Office of the Chief Scientist, 2012). The definition of STEM used in that report included only natural and physical sciences, information technology and engineering. An initial analysis of recent data provides an interesting picture (Figure 2-1).

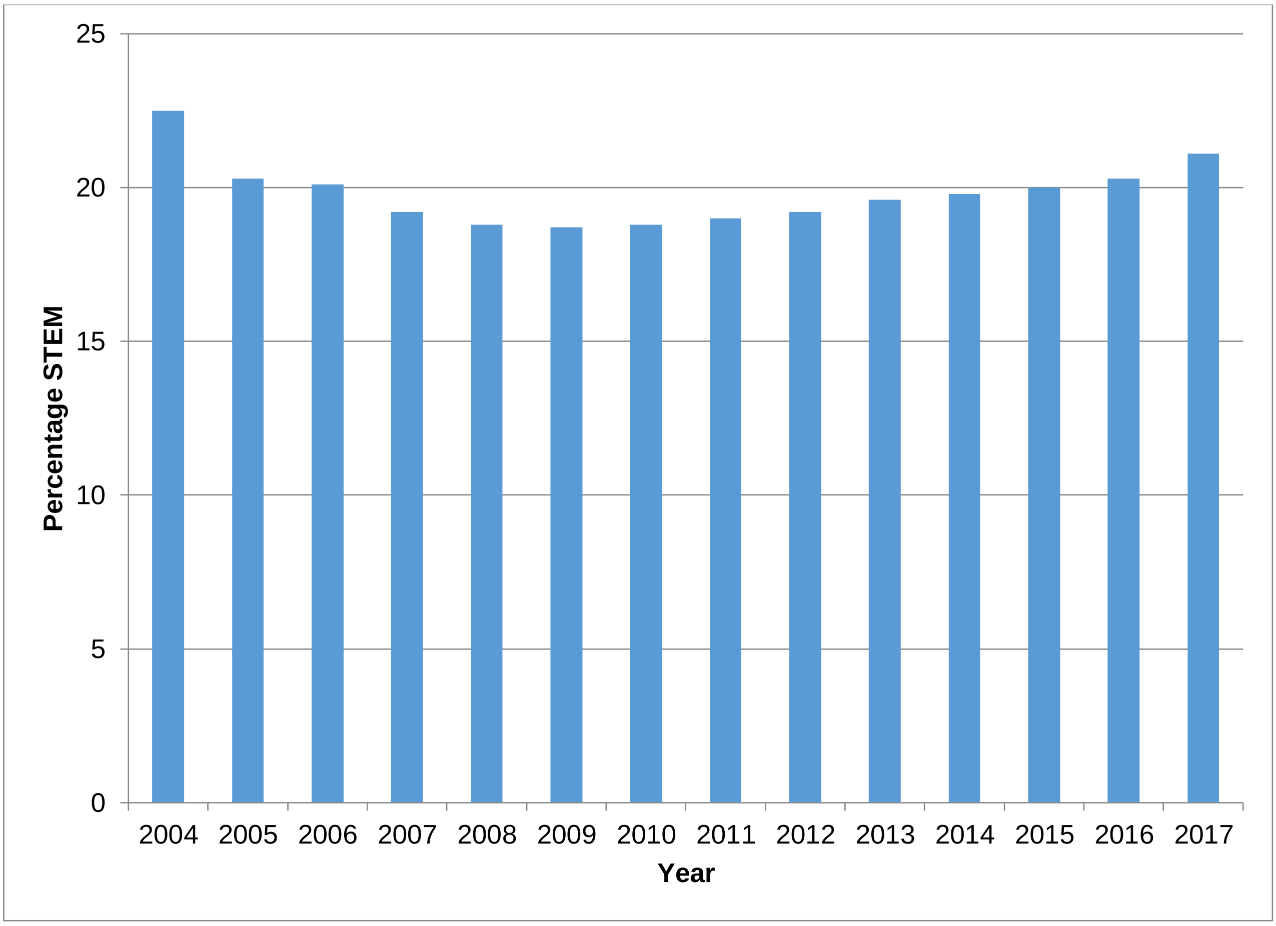

Figure 2-1. Percentage of university STEM enrolments – Natural and Physical Sciences/Information Technology/Engineering.

Source: Department of Education and Training (2004-2017).

University STEM enrolments declined steadily from 2004 to 2008/09, around the time of the global financial crisis and potentially the mining/construction consumers decreased demand for STEM graduates, followed by a steady increase from that point on to 2017.

Initial analyses have shown that at the senior secondary level, the decreased level of STEM enrolment is clear. In South Australia, enrolment numbers in most STEM subjects decreased from 2003 to 2016, apart from Psychology and Nutrition (increased), and Agriculture (remained steady) (see Figure 2-2).

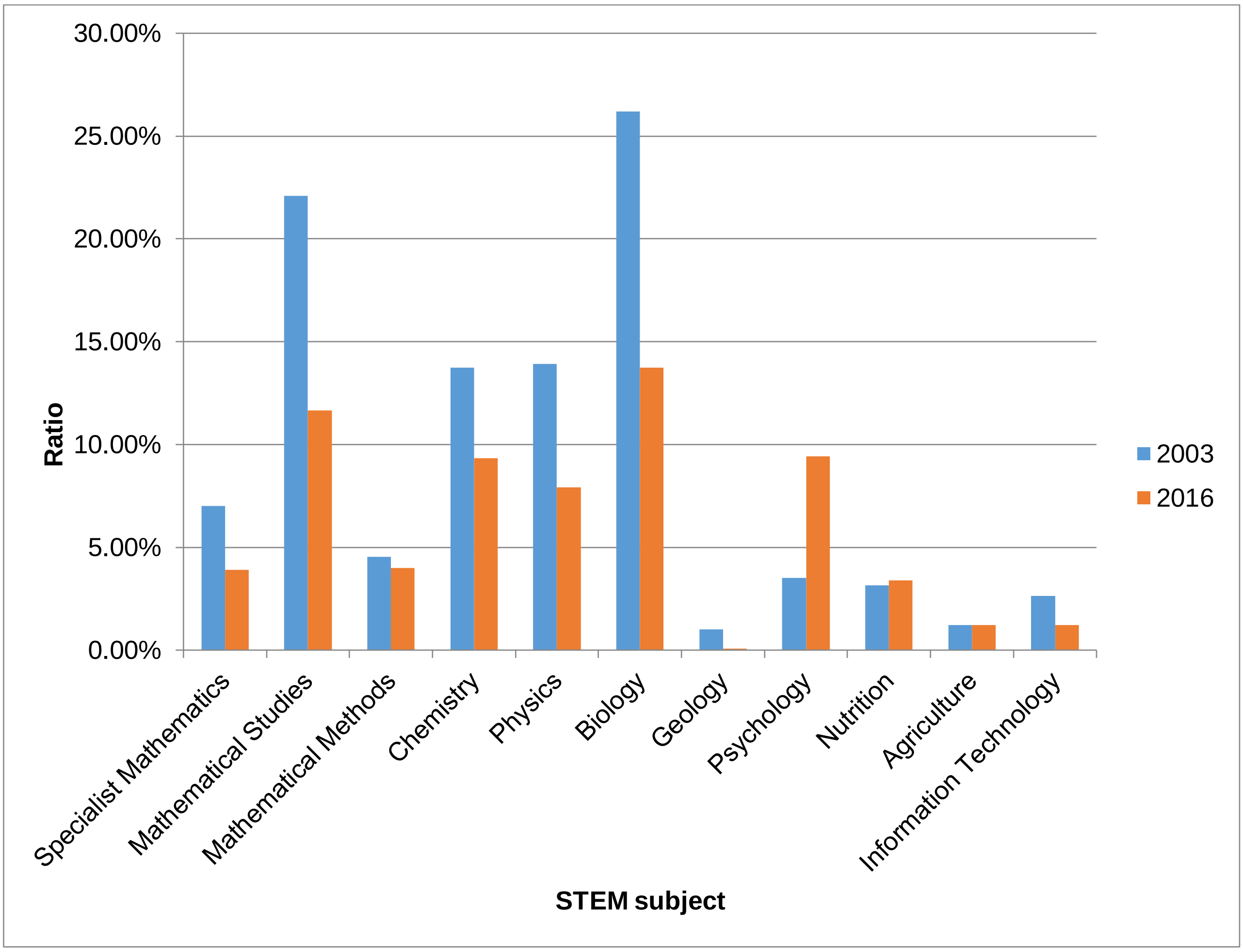

Figure 2-2. Percentage of SACE Stage 2 STEM enrolments.

Source: SACE Board of South Australia (2003-2016).

The increase in Psychology was potentially due to the subject being newly introduced to SACE. The introduction of the research project into the SACE impacted the number of Year 12 subjects that students are required to undertake in order to be eligible for university entrance. Prior to the introduction of the research project in 2011, students typically completed five Year 12 subjects in order to gain entrance to university, compared to the current norm of four Year 12 subjects and the research project. Although this change may have impacted the enrolment numbers it is difficult to determine the extent of its influence. Some students may still be gaining STEM related skills through enrolment in the research project if the focus of the project is on an application of STEM or utilises STEM related skills in its investigation. Data on the nature of topics covered was not located at the time of the research. A recent review of the current Year 12 SACE (Stage 2) structure has been undertaken with the resultant suggestion to reverse the decision that made the research project compulsory in the final year of schooling. A more detailed discussion of this is provided in Section 2.5.5.6. A more in-depth investigation into the various factors that influence the STEM enrolment decisions of Australian students is warranted.

With the increasing demand for scientifically and technologically trained people in the workforce (Abraham, 2011; Clyne, 2014; Office of the Chief Scientist, 2013; PricewaterhouseCoopers Australia, 2015), the declining enrolment numbers of students in STEM subjects is worrying. Since the development of computers and continually advancing technology that has resulted in the internet, mobile phones and social media, the landscape of working environments has changed dramatically (Siekmann & Korbel, 2016). Traditional jobs that require low levels of creativity, social interaction, mobility and dexterity will likely be replaced by automation (Siekmann & Korbel, 2016). The importance of developing students' STEM skills and associated skills in critical and creative thinking is a matter of concern for education systems and societies globally.

The dawn of the age of technology, or *The Fourth Industrial Revolution* as Schwab (2017) refers to it, requires citizens to be able to cope with the rapidly changing nature of work and the demands that the advancement of technology has placed on it. Schwab (2017) believes that:

> The more we think about how to harness the technological revolution, the more we will examine ourselves and the underlying social models that these technologies embody and enable, and the more we will have an opportunity to shape the revolution in a manner that improves the state of the world (p. 4).

The Department of Further Education, Employment, Science and Technology (DFEEST) (2011, 2014) in South Australia argued that a workforce well versed in STEM skills is necessary to cope with the increasingly technological and digital economy. The Australian Industry Group (2015) cited international estimates that “75% of the fastest growing occupations require STEM skills and knowledge” (2015, p. iii). A survey of employers within Australia cited the difficulty of recruiting workers with STEM skills, in particular “recruiting technicians and trades workers (41%), professionals (27%) and managers (26%) with these skills across different industries” (Australian Industry Group, 2015, p. iii). Timms, Moyle, Weldon and Mitchell (2018) summarised that “falling levels of achievement in STEM and falling numbers of people studying STEM at advanced levels become a downward spiral, at the very time when the demand for STEM literacy is spiralling upward“ (p. 4).

The importance of STEM for the constantly changing global economy has been well documented. STEM skills are seen to be necessary skills for the future and vitally important for innovation and economic growth (Productivity Commission, 2016). Governments worldwide have expressed concerns over the declining engagement in STEM and the adverse effect this is projected to have on economic growth and scientific and technological advancement (Cole, 2013). In the US, there has been a push for an increase in STEM major enrolments “to sustain or reclaim higher levels of U.S. workforce productivity in the global economy” (Lee, 2011, p. iv). The National Science Board (2007) declared that education and subsequent career recruitment in STEM is a national priority. Deloitte (2012) reported that in 2010, “mathematical science research in the UK generated direct GVA [gross-value added] in excess of £200 billion” (2012, p. 24), which is around 16% of total UK GVA. The increased level of global competitiveness requires individual countries and regions to further advance education and investment in STEM (Kennedy & Odell, 2014; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2010).Locally, the evolving nature of the economy demands its citizens to be more mathematically, technologically and scientifically literate (Clyne, 2014). It is important for the role of STEM in education to be recognised as vital to processes "of innovation and economic growth, and to recognise the transformations they are effecting in social and cultural life" (Engineers Australia, 2007, p. 1). PricewaterhouseCoopers Australia (2015) assert that the broad skills that people educated in STEM acquire such as critical thinking, problem solving, and imagination have been identified as vitally important for the changing nature of the workforce. The need for the Australian public to be capable of making informed decisions on important topical issues is critical for the prosperity of the nation (Engineers Australia, 2007; Office of the Chief Scientist, 2013). As the nation's productivity is under pressure, the Australian Industry Group (2015) recommended that our school leavers need to develop skills in STEM. Currently, productivity levels in Australia are falling and PricewaterhouseCoopers Australia (2015) have claimed that "shifting just 1 per cent of the workforce into STEM roles would add $57.4 billion to GDP (net present value over 20 years)" (2015, p. 4). Many of the reports that call for citizens to be more adequately equipped with STEM skills are not clear about the level of those STEM skills, referring to the binary nature of an all-encompassing STEM (Curtis & Jeffries, 2017). It is clear that there is a very modest demand for very high level STEM skills, but there is a very great demand for 'medium' levels of STEM knowledge and skills (Curtis & Jeffries, 2017). The Office of the Chief Scientist (2013) reminded us that "STEM is everywhere. Our nourishment, our safety, our homes and neighbourhoods, our relationships with family and friends, our health, our jobs, our leisure are all profoundly shaped by technological innovation and the discoveries of science" (2013, p. 5). It is evident that the two key themes that have been addressed, STEM worker shortage and STEM skills shortage, are both vitally important and contentious areas in need of research.

2.2.3. STEM and the workforce: a summary

In summary, international research has highlighted the need for citizens to be equipped with both STEM skills and those that are often developed through inquiry in STEM, such as critical and creative thinking and problem solving. Although there is contention surrounding the purported STEM workforce shortages in Western countries, the value of STEM education in the rapidly advancing technological society and globalised economy is clear. Therefore, the decline over recent decades of students enrolling in STEM subjects in secondary school and in STEM majors at university provides a justification for the investigation into STEM subject choice in Year 12. In order to fully understand the educational context in which students are engaging with STEM education, it is important to evaluate the policy initiatives and research report findings within the Australian and South Australian context. This is outlined in the next section.

2.3. Policy initiatives and research reports in STEM education

A series of research reports and policy initiatives have been produced and enacted on both national and state levels. A selection of the most prominent of these is discussed in the following Sections (2.3.1. and 2.3.2.).

2.3.1. Context in Australia

Over the last 10 years in Australia many policies and strategic reports related to STEM education have been produced by various federal and state government departments, curriculum bodies, education associations and private research consultancy firms. Many of them have addressed issues related not only the development of STEM specific skills and the economic rationalisations for producing STEM literate citizens, but also for developing the 21st century skills and general capabilities needed to produce collaborative, critical and creative thinkers in Australian society. In 2008, education ministers from all states and territories within Australia signed the *Melbourne Declaration on Educational Goals for Young Australians* (Ministerial Council on Education Employment Training and Youth Affairs, 2008). This declaration outlined the goals for Australian schools to promote equity and excellence, ensuring all students would become successful learners, confident and creative individuals, and active and informed citizens. The declaration included elements relating to skill development in literacy, numeracy, critical and creative thinking, problem solving and digital technologies (Education Council, 2015).

In response to the *Melbourne Declaration*, a national STEM school education strategy 2016 – 2026 was developed and signed by all Australian education ministers. The objectives previously addressed in the *Melbourne Declaration* "lie at the core of the national science, technology, engineering and mathematics (STEM) school education strategy" (Education Council, 2015, p. 3). The strategy highlighted two overarching goals (Education Council, 2015):

1. All students finish school with strong foundational knowledge in STEM and related skills; and
2. Students are inspired to take on more challenging STEM subjects (p. 5).

As a result of the second goal, an area identified as requiring national action was "increasing student STEM ability, engagement, participation and aspiration" (Education Council, 2015, p. 6). In the same year (2015), the Australian Government Minister for Industry, Innovation and Science announced the release of the National Innovation and Science Agenda (NISA) report. The NISA committed $1.1 billion over four years to address four key identified areas of need, namely culture and capital, collaboration, talent and skills, and government as an exemplar (Commonwealth of Australia, 2015). Impacting schools directly were the measures of supporting the teaching of coding, giving teachers more time to teach science and mathematics, and ensuring that newly trained primary teachers graduated with a subject specialisation (priority for STEM) (Commonwealth of Australia, 2015). Targeted initiatives were developed as a result of these measures relating to developing citizens' digital and computing literacy (coding challenges, encouraging teacher adoption of digital technologies and Scientists and Mathematicians in Schools (SMiS)), increasing opportunities for girls/women in STEM (celebrate role models) and improving STEM literacy (science and mathematics competitions, STEM inquiry based play and STEM based community events) (Commonwealth of Australia, 2015). At the same time as the national STEM strategy was being outlined and the NISA report released, the Australian Curriculum, Assessment and Reporting Authority (ACARA) undertook the STEM Connections Project in conjunction with the Australian Association of Mathematics Teachers (AAMT) to investigate the effectiveness of integrating STEM disciplines using project based learning (Australian Curriculum Assessment Reporting Authority, 2016). This project addressed many of the areas identified in the national STEM strategy. STEM in the Australian curriculum was viewed as relating to elements within the “learning areas of Science, Technologies and Mathematics, and through general capabilities, particularly Numeracy, Information and Communication Technology (ICT) capability, and Critical and Creative Thinking” (Australian Curriculum Assessment Reporting Authority, 2016, p. 6). As a result of taking an integrated approach to teaching STEM, many benefits to student learning were purported to follow, such as the use of engaging content, making connections between content areas, developing authentic learning experiences in connection with an industry partner, improving collaborative skills, improving communication skills and further developing capabilities for 21st century learning (Australian Curriculum Assessment Reporting Authority, 2016). However, some barriers to adopting this approach were identified including the commitment and expertise required of staff, implementation difficulties due to an inflexible structure within traditional school settings (e.g. subjects and timetables) and variation in level of content coverage of all learning areas within a single project if adequate prior planning was not completed (Australian Curriculum Assessment Reporting Authority, 2016). In early 2015, the Australian Industry Group was commissioned by the Office of the Chief Scientist to “address the issue of declining Science, Technology, Engineering and Mathematics (STEM) skills through a project to strengthen school-industry STEM skills partnerships” (Australian Industry Group, 2017, p. 8). Through fostering relationships between schools and industry, the project attempted to increase participation of secondary students in STEM subjects, improve understanding (teachers’ and students’) of STEM and its application in the workplace, and increase students’ education and career aspirations for STEM (Australian Industry Group, 2017). The AiG’s strategy in implementing this pilot program was to assess various companies’ willingness to help and level of commitment, identifying sources of funding, identifying criteria for successful models and assessing current successful models that could be replicated in order to implement the pilot program (Australian Industry Group, 2017). One of the tangible and valuable outcomes of the project was the development and dissemination of the STEM Programme Index (SPI 2016) which outlined 250 programs and initiatives relating to STEM education and collaboration between schools, universities, businesses, science and education agencies and government departments (Australian Industry Group, 2017). This resource provided teachers across Australia with information relating to

STEM resources, competitions and engagement programs (Australian Industry Group, 2017).

In 2017, the United Nations Educational, Scientific and Cultural Organization (UNESCO) released a report addressing girls' and women's engagement and achievement in STEM education as a response to one of the sustainable development goals outlined in *The Global Education 2030 Agenda* had been released two years earlier (United Nations Educational Scientific and Cultural Organization, 2017). The intended purpose of the report was to "stimulate debate and inform STEM policies and programmes at global, regional and national levels" (United Nations Educational Scientific and Cultural Organization, 2017, p. 16). Many issues were highlighted, particularly an outline of levels of females' participation and achievement in STEM, factors that influenced these outcomes, and interventions that may help to improve the interest and sustained engagement of females in STEM (United Nations Educational Scientific and Cultural Organization, 2017). Perhaps as a result of UNESCO's *The Global Education 2030 Agenda* and a continuation of the NISA, the *Australia 2030: Prosperity through innovation* report was released, outlining a number of key areas to address for the nation to compete in the 'global innovation race' (Innovation and Science Australia, 2017). The vision for Australia highlighted in the report is that through innovative science and research, economic growth, competitive industry and collaborative education, increased number of meaningful/productive jobs and an equitable and high quality of life for all citizens will ensue (Innovation and Science Australia, 2017). One of the five imperatives for action that was discussed to ensure this vision was achieved was related to education, responding to the skill requirement of citizens due to the changing nature of the workforce (Innovation and Science Australia, 2017). A key strategic initiative as part of the education imperative was to improve the teaching of STEM and 21st century skills through professional development for teachers (Innovation and Science Australia, 2017). Educational inequality was to be addressed through targeted interventions within schools that were performing significantly below the national average (Innovation and Science Australia, 2017).

A particular emphasis was also placed on the promotion of young female's participation in STEM in Australia, emphasised by the report produced by Chapman and Vivian (2017) utilising international best practice to identify areas of concern and key points of action, namely:

1. A national strategy to build STEM teacher quality;
2. An industry led project to develop the STEM capacity of existing teachers;
3. Mapping the current STEM landscape;
4. Developing a STEM framework to guide stakeholders;
5. Increase engagement opportunities, particularly highlighting positive examples of women in STEM;
6. Industry led research into areas of need in STEM education;
7. A national STEM mentoring program; and
8. Developing a range of STEM resources (Australian STEM context).

Recently, a policy insights document was disseminated by Timms et al. (2018), which highlighted three key challenges facing STEM learning in Australian schools based on a review of the literature and existing policy documents. The first challenge was to develop effective strategies to enhance STEM outcomes (interest, participation and skills) for students through longitudinal monitoring, early intervention practices, specialist STEM schools and academies and out-of-school programs. The second challenge that was identified was to improve the STEM teacher workforce by collecting better data on the teaching workforce as a whole and offering incentives for pre-service teachers to be trained and to work as a specialist STEM teacher (Timms et al., 2018). Finally, the STEM curriculum needed to be adjusted to include a universally agreed upon definition of what constitutes STEM education, emphasising the practices of STEM thus working towards an integrated STEM curriculum (Timms et al., 2018). In 2019, the Australian Academy of Science (2019) released the *Women in STEM Decadal Plan* report addressing the gender disparity in Australia's STEM skilled workforce. In order to achieve gender equity, they listed six potential opportunities to improve the situation if enacted with a commitment by relevant stakeholders including state and federal government, the academic community, industry leaders, education sector and the wider community.

One of those areas was education, with the identification of the need to strengthen:

> the education system to support teaching and learning on a national scale [that] will enable and encourage all girls and women at all levels to study STEM courses and equip them with the skills and knowledge to participate in diverse STEM careers (Australian Academy of Science, 2019, p. 14)

In order to achieve this goal they recommended that all STEM teachers in school be provided with specific STEM professional learning (pre-service and in-service) with priority given to teachers in schools with low female STEM participation rates. Further, curriculum authorities, subject and career advisors, government departments, industry and parents should all work together to ensure that female students are aware of a range of STEM careers, understand the real world applications of STEM, be provided with relevant STEM learning and access to information resources, have access to informal STEM education opportunities, can challenge stereotypes, and are able to have constructive and informed discussions about STEM from an early age (Australian Academy of Science, 2019). However, Dockery and Bawa (2018) warn that focussing solely on increasing female participation in STEM may be a mistake due to various barriers that females face in STEM careers when compared with females in non-STEM fields. A more detailed discussion is provided in Section 2.5.5.1.

2.3.2. Context in South Australia

In South Australia, a STEM learning strategy (2017-2020) was developed for education from pre-school through Year 12 to provide "every student with the chance to develop the capabilities they will need, as our future innovators and problem-solvers" (Department for Education and Childhood Development, 2016, p. 1). Two key challenges they hoped to overcome by 2020 were to:

1. Increase the number of students enrolling in physics, chemistry and advanced mathematics; and
2. Improve opportunities to those students who are currently under-represented (female, indigenous and low SES students) (Department for Education and Childhood Development, 2016).

The three objectives outlined in the strategy were:

1. To implement STEM learning from pre-school through Year 12;
2. Systemic improvement in STEM teaching and learning; and
3. Build partnerships between business, industry and schools.

As part of the strategy, the South Australian government provided $250m of funding to build/renovate new/existing buildings in 139 schools to create specialist STEM spaces. Along with this funding, $100m was used to build a new specialist secondary school in the Adelaide CBD with a focus on STEM and health sciences. A further project was established to train 500 primary teachers as STEM specialists.

2.3.3. Policy initiatives and research reports in STEM education: a summary

In summary, Section 2.3. has outlined various policy initiatives and research reports internationally, nationally and in South Australia pertinent to the context of the research explored in this thesis. The policy implications and recommendations made to stakeholders likely influenced the operations of STEM education at various levels of education, including how teachers engage with STEM curriculum and the learning activities that students experience in schools. These initiatives were designed to increase participation and achievement in STEM, especially among under-represented groups. Given the view that greater participation in STEM is required, it is necessary to understand the factors that influence students' decisions about STEM participation. This is addressed in the next section.

2.4. Behaviour and choice

An overwhelming concern for the state of STEM in Australia is the decreasing number of students enrolling in STEM subjects in Year 12. The decision-making process a student goes through during subject selection is complex and multi-faceted (Bøe et al., 2011; Henriksen et al., 2015; James, 2007). In Section 2.4.1., alternative theories of choice and behavioural prediction are discussed with an argument presented for using the theory of TPB as the guiding framework in the literature review and throughout the study. Sections 2.4.2. to 2.4.9. elaborate on the more detailed aspects of the TPB and how it relates to educational decision making. Section 2.4.10. outlines how the TPB is used in the context of the current study. Section 2.4.11. provides a summary of the ideas explored throughout the section on behaviour and choice.

2.4.1. Theories of behaviour and choice

In order to effectively evaluate the complex nature of the decision-making process that students go through when choosing subjects for Year 12, a conceptual framework was needed to guide the analysis and interpretation of results. Several alternative theories of choice in education and psychology literature, most notably social cognitive career theory (SCCT) (Lent, Brown, & Hackett, 1994), expectancy-value theory of achievement motivation (EVT) (Eccles et al., 1983; Wigfield, 1994; Wigfield & Eccles, 2000) and the TPB (Fishbein & Ajzen, 2010) are considered.

SCCT is predominantly focused on career related aspirations and choices but is equally applicable to academic choice. Its foundation is derived from Bandura's (1986) social cognitive theory which attempted to explain the interactive influence between a person, their behaviour and environment in a particular way termed *triadic reciprocality* (Lent et al., 1994). The most notable outcome of Bandura's theory was the concept that self-efficacy is not simply a "passive, static trait, but rather is seen as a dynamic set of self-beliefs that are specific to particular performance domain and that interact complexly with other person, behavior, and contextual factors" (Lent et al., 1994, p. 83). The adaptation of Bandura's theory, the SCCT, was the result of an attempt to integrate several competing models to explain the mechanism through which interests are formed, choices are developed and outcomes are achieved (Lent et al., 1994).

The EVT is a conceptual model that attempts to explain how an individual's motivation and beliefs influence their achievement-related choices, persistence and performance (Wigfield & Eccles, 2000). The choice an individual makes is directly influenced by their expectancies of success and subjective task value (enjoyment, utility value, and cost) (Wigfield & Eccles, 2000). The expectancy and subjective task value constructs are directly influenced by an individual's goals, self-schema (self-concept and self-efficacy) and affective memories, and are indirectly influenced by a number of variables including locus of control, gender roles, attitudes, cultural stereotypes, prior achievement-related experiences and aptitudes (Wigfield & Eccles, 2000).

The TPB as described by Fishbein and Ajzen (2010) is a conceptual model that attempts to explain behaviours. The theory suggests that a particular behaviour (observable act) can be predicted by "the person's intention to perform that behaviour" (Fishbein & Ajzen, 1975, p. 16). Intention is determined by three factors: attitude towards the behaviour (positive or negative perception), subjective norms (perception of whether to perform the behaviour as influenced by social pressures) and perceived behavioural control (perception of level of volitional control) (Fishbein & Ajzen, 2010). These constructs are informed by an underlying set of salient beliefs, namely behavioural beliefs, normative beliefs and control beliefs (Fishbein & Ajzen, 2010). Indirectly influencing the formation of this set of beliefs is a variety of background variables such as demographic, personality and other individual factors (Fishbein & Ajzen, 2010).

2.4.2. Previous studies using the TPB

The TPB is a useful framework for investigating a complex human social behaviour (Ajzen, 1991). Conner and Armitage (1998) argued that the TPB is an ideal model in determining variance among choice behaviours. Many researchers have utilised a variation of the TPB model in choice related studies. Armitage and Conner (2001) conducted a meta-analysis of 185 independent studies (until 1997) using the TPB in a variety of research contexts. Ajzen (1991) discussed TPB research related to video games, job searching, alcohol consumption, election participation, weight loss, test cheating, leisure activities and a variety of other choice related behaviours. Albarracin, Johnson, Fishbein and Muellerleile (2001) completed a meta-analysis which incorporated 96 data sets relating solely to the TPB as a model of condom use. A meta-analysis completed by Hausenblas, Carron and Mack (1997) reported 31 studies using a version of the reasoned action model (pre-cursor to TPB) relating to exercise behaviours. In relation to the current study, several researchers (Crawley & Black, 1992; Crawley & Coe, 1990; Crawley & Koballa, 1992; Dalgety & Coll, 2004; Freeney & O'Connell, 2012; Khoo & Ainley, 2005; Taylor, 2015) have utilised the TPB when investigating the subject choice behaviour of students. The UK study by Taylor (2015) found that the TPB was an appropriate framework for examining senior secondary subject choice.

The SCCT (Lent et al., 1994; Rowan-Kenyon et al., 2012), EVT (Abraham & Barker, 2014; Wang & Degol, 2013), and TPB (Khoo & Ainley, 2005; Taylor, 2015) have all been previously used to investigate the educational decisions of students at various levels of education. However, the TPB was chosen as the conceptual framework that guided the remainder of the literature review, development of the research methodology, analyses of results, and interpretation of findings. Although some have been critical of the continued use of the TPB to investigate health related behaviour (Sniehotta, Presseau, & Araújo-Soares, 2014), the original developer of the theory rebutted their sentiments stating that some of "their arguments are misguided, resting on a poor understanding of the TPB and of the nature of psychological research, while others are illogical or patently wrong" (Ajzen, 2015, p. 131). In order to understand both the facilitators and barriers to students' decisions of whether to enrol in a STEM subject in Year 12, consideration needs to be given to their intentions for future choice, subsequent decisions and if the two do not match, the reasons for the alternative pathway. Therefore, the TPB with its emphasis on background characteristics, attitudes, perceived norms and perceived behavioural control leading to intention and behaviour seemed an appropriate choice as the guiding conceptual framework for this study.

2.4.3. Development of the TPB

In order to discuss the TPB an examination of the origin of the model is needed. The theory of reasoned action (TRA) as described by Fishbein and Ajzen (1975) is a conceptual framework that attempts to explain behaviour. According to the TRA, a person's intention to perform a particular behaviour is determined by two factors: attitude towards the ¾haviour (positive or negative perception) and subjective norm (perception of whether to perform the behaviour as influenced by social pressures) (Ajzen & Fishbein, 1980). These constructs are informed by an underlying set of salient beliefs, namely behavioural beliefs and normative beliefs (Ajzen & Fishbein, 1980). Indirectly influencing the formation of these beliefs is a variety of background variables such as demographic, personality and other individual factors (Ajzen & Fishbein, 1980). In later work, Ajzen (1985, 1988) added a third construct to the TRA. Understanding that intentions and behaviour are "not under complete volitional control" (Fishbein & Ajzen, 2010, p. 18), Ajzen (1985, 1988) introduced the construct perceived behavioural control, with an underlying control belief. This extension of the TRA is called the TPB. The version of the model proposed by Fishbein and Ajzen (2010) that is used in this research is presented in Figure 2-3.

Image removed due to copyright restriction.

Figure 2-3. The TPB model.

Source: Fishbein and Ajzen (2010, p. 22)

2.4.4. Intentions and predicting behaviour

Intentions can be viewed as "indications of a person's readiness to perform a behaviour" (Fishbein & Ajzen, 2010, p. 39). Contention surrounds the idea of intentions being a sufficient construct to predict actual behaviour, although Khoo and Ainley (2005) used regression analyses to show that the relationship between students' intentions and subsequent decisions to participate in Year 12 is strong ($B = 0.967$ *(0.042)*, $p < 0.001$). Fishbein and Ajzen (2010) proposed that it should be possible to predict behaviour directly from intentions, should the indicators of measure for each item conform with the principle of compatibility, as outlined in Ajzen and Fishbein (1980). The principle of compatibility argues that:

> "an intention is compatible with a behaviour if both are measured at the same level of generality or specificity – that is, if the measure of intention involves exactly the same action, target, context, and time elements as the measure of behaviour" (Fishbein & Ajzen, 2010, p. 44).

Other variables may influence the magnitude of the intention-behaviour relationship. Temporal stability of the relationship, measured by the correlation between the two, can vary depending on context and the elapsed time between an intention and subsequent behaviour (Fishbein & Ajzen, 2010). Attitudes towards the behaviour, perceived norms, perceived behavioural control and background factors determine the intention to perform a behaviour (Ajzen, 1991; Ajzen & Sheikh, 2013; Fishbein & Ajzen, 2010). The four constructs vary in their relative contribution to intention depending upon individual, group and behavioural context (Ajzen, 1991; Fishbein & Ajzen, 2010).

2.4.5. Attitude towards the behaviour

Attitude can be defined as "a latent disposition or tendency to respond with some degree of favourableness or unfavourableness to a psychological object" (Fishbein & Ajzen, 2010, p. 76). In the TPB, the relationship between beliefs and attitude were taken from the work of Feather (1959, 1982) and Fishbein (1963). The attitude construct is formed directly and automatically from behavioural beliefs about the object informed by various attributes, characteristics, and qualities (Fishbein & Ajzen, 2010). Symbolically, the relationship is:

$$A \propto \sum b_i e_i$$

"where A stands for attitude toward an object, b_i is the strength of the belief that the object has attribute *i*, and e_i is the evaluation of attribute *i"* (Fishbein & Ajzen, 2010, p. 97).

2.4.6. Perceived norm

A social norm as theorized in social science is a construct that relates to the acceptable behaviour of an individual within a group or society (Fishbein & Ajzen, 2010). In the TPB, perceived norm is based on a person's perception of social norms. Norms are viewed as "perceived social pressure to perform (or not perform) a given behaviour" (Fishbein & Ajzen, 2010, p. 130). As perceived social pressure increases, the intention to perform the behaviour will increase. A distinction is made between injunctive norms (perception about what others would want them to do) and descriptive norms (perception about whether others are performing the behaviour). Injunctive norms refer more to a specific belief about how an individual or group might want the person to behave and are formed from normative beliefs held by an individual (Fishbein & Ajzen, 2010). With descriptive norms, the TPB assumes that "a person's own behaviour is influenced by the perceived behaviour of others" (Fishbein & Ajzen, 2010, p. 145). Although injunctive and descriptive norms can be congruent or contradictory, they can coexist and lead to the formation of the perceived norm construct within the TPB (Fishbein & Ajzen, 2010).

2.4.7. Perceived behavioural control

A major influencing factor in the success of an intention resulting in a particular behaviour is the level of volitional control (Fishbein & Ajzen, 2010). Although difficult to examine the actual level of perceived behavioural control, Fishbein and Ajzen (2010) suggested that a person's perception about their control over a decision is an accurate measure of actual control. For this reason, volitional control in the TPB is defined as perceived behavioural control. It is viewed as a two dimensional construct, acting as a moderating variable on the intention-behaviour relation and as having an additive effect on the measure of intention (Fishbein & Ajzen, 2010). This means that it not only impacts the formation of an intention but, if perceived behavioural control is high, the likelihood of the behaviour occurring is high. There are various internal (skills and willpower) and external (task demands and actions of others) factors that influence perceived control (Fishbein & Ajzen, 2010). The beliefs a person has about these control factors determine the level of perceived behavioural control (Fishbein & Ajzen, 2010).

2.4.8. Background factors

Indirectly influencing the set of beliefs that have a direct influence over an individual's intention and subsequent behaviour is a diverse range of background factors. Behavioural, normative and control beliefs are defined as subjective probabilities of the performance of a behaviour (Fishbein & Ajzen, 2010). These beliefs can be observational (behaviour results in particular outcome), informational (TV, radio, internet, magazines) or inferential (perception about how a behaviour might result in a particular outcome) (Fishbein & Ajzen, 2010). Differences in beliefs are based on a person's interaction with the world and different learning experiences. The TPB uses background factors that are relevant to the behaviour under examination and based on theory to help explain the formation of beliefs (Fishbein & Ajzen, 2010). Variables such as gender, ethnicity, personal dispositions, motivation, interest and social environment may influence beliefs, intention and subsequent behaviour.

2.4.9. Criticisms and misconceptions

Ogden (2003) criticised the use of the TPB in predicting choice behaviour. She argued that many studies using the TPB attempted to test or apply the theory without providing explanation for the unexplained variance, simply providing reasoning such as wording, lack of data and population/behaviour as the issue. Weinstein (2007) further supported these claims suggesting that many studies that incorporated cognitive theories of behaviour (including TPB) relied on correlational analysis to explain causation, exaggerated predictive accuracy, and attempted to test the theory without discussing validity or completeness.

Ajzen and Albarracin (2007) discussed two common misconceptions of the TPB. The first is that people are assumed to act rationally within the reasoned action model. They highlighted that theory simply implies that behavioural intentions are formed from a set of beliefs that, "although often quite accurate, can be biased by a variety of cognitive and motivational processes" (Ajzen & Albarracin, 2007, p. 8). However, once beliefs are formed, intentions will follow in a consistent and coherent fashion. The second misconception is that people are consciously aware of every intention before the behaviour is carried out. Although this may be the case in some scenarios, the theory suggests that once behaviours are performed multiple times, they become routine. This does not mean that intentions are not formed before behaviour, simply that "the intentions are activated spontaneously without much conscious effort" (Ajzen & Albarracin, 2007, p. 9).

Although the TPB has previously been criticised and alternative theories of behaviour and choice such as the SCCT and EVT could have been chosen to guide this study, the TPB was shown in Sections 2.4.2. to 2.4.8. to be an adequate model for investigating the psychological constructs underlying human decision making. The theoretical constructs of intentions, attitudes, perceived norm, perceived behavioural control and various background factors were outlined. In the next section, the context in which the TPB was used in this study is explained.

2.4.10. TPB in the context of the current study

A review of the literature on TPB and its applicability in this context suggests that background factors should be categorised as either student or school related factors. Figure 2-4 presents an adapted version of the TPB within the current research context and is used as the guiding framework for the remainder of the literature review and subsequent data collection, analysis and interpretation of results.

Image removed due to copyright restriction.

Figure 2-4. Adapted TPB model.

Source: Modified after Fishbein and Ajzen (2010, p. 22)

In Figure 2-4, an adapted conceptual framework is presented based on Fishbein and Ajzen's 2010 model (see Figure 2-3). In the current research, the construct 'Background factors' is split into two categories, namely 'Individual' factors and 'School' factors. The other elements within the original TPB model, including 'Attitude toward the behaviour', 'Perceived norm', 'Perceived behavioural control', 'Intention' and 'Behaviour' have remained in the adapted framework situated within the context of this research, i.e. 'Behaviour' is 'STEM subject choice in Year 12'.

2.4.11. Behaviour and choice: a summary

In summary, three theories of predicting behaviour and choice have been presented namely the SCCT, EVT and TPB. These theories have previously been used to investigate psychological concepts underpinning the educational decisions of students at various levels of education. The TPB was chosen as the conceptual framework guiding this study. The development of the TPB and the various elements within the model (intention, attitudes, perceived norm, perceived behavioural control and background factors) were outlined in more detail in Sections 2.4.3. – 2.4.8. An adapted TPB was presented in Section 2.4.10. which situated the theory within the context of this research.

2.5. Factors that influence STEM subject choice

International research has highlighted a number of possible factors influencing a student's choice of STEM subjects at various levels of education. The TPB outlines how intentions, attitudes towards a behaviour, perceived norms, perceived behavioural control and background factors can all exert influence over students' decisions to behave in a particular way. The remainder of this chapter is structured in line with the guiding conceptual framework (TPB) described above. Research relating to STEM intentions, attitudes, perceived norms, perceived behavioural control and various background factors are explored in the following sections (2.5.1. to 2.5.5.).

2.5.1. Intentions to enrol in STEM

STEM career aspirations have been shown to be major influences on students' interest and enrolment in STEM subjects at secondary and tertiary levels of education (Archer et al., 2012; Gore et al., 2017; Henriksen et al., 2015; Lyons & Quinn, 2010). Gottfredson (2002) argued that career aspirations developed from early childhood, narrowing as the student became older. By the age of 15, students' career aspirations had become defined and educational choices were influenced by their aspirations. In this way, educational and career aspirations for STEM pathways during schooling years (early childhood, primary and middle) could be seen as a proxy for an intention to pursue STEM education at the senior secondary and tertiary levels.

In the UK, students' uptake of Year 11 and 12 subjects was found to be influenced by their future career aspirations and perceived usefulness of subjects for those careers, particularly with mathematics and science subjects (Vidal Rodeiro, 2007). A more recent longitudinal study in the UK examined the science career aspirations of students aged between 10 and 14 years and the factors that influenced their aspirations using multilevel regression analyses (DeWitt & Archer, 2015). Demographic variables such as gender, ethnicity, and cultural capital were contributing factors, with females, white students, and students with low cultural capital being less likely to hold science career aspirations than their counterparts (DeWitt & Archer, 2015). Whilst prior performance, self-concept, participation in science-related activities and having a parent working in a science related career exerted some influence, both students' and parents' attitudes towards science had a significant effect on students' science career aspirations (DeWitt & Archer, 2015).

In a US study, it was found that students who had science career aspirations during middle school (Year 8) were more likely to complete undergraduate degrees in life sciences, physical sciences or engineering (Tai, Liu, Maltese, & Fan, 2006). The study also emphasised the influence over other major factors that career aspirations could have on students' future enrolment in science university majors, describing how an "average mathematics achiever with a science-related career expectation has a higher probability of earning a baccalaureate degree in the physical sciences or engineering than a high mathematics achiever with a non-science career expectation, 34% versus 19%" (Tai et al., 2006, p. 1144). A follow up study by Maltese and Tai (2011) examined the effect of subject enrolment in the high school years on tertiary enrolment, finding that students who undertook studies in biology, chemistry, physics or advanced mathematics were more likely to complete a STEM degree at university.

Using survey data of 3,759 students across Australia at the end of Year 10 following subject selection going into Year 11, Lyons and Quinn (2010) stated that 60% of the sample chose a science subject(s) in Year 11 due to needing it for university or subsequent career aspirations. A longitudinal study in NSW conducted by Gore et al. (2017) found many student and school related variables which influenced school students' aspirations for specific careers that required university level education.

They found that students' aspirations for a career in social and welfare related areas, nursing and engineering increased in the later years of schooling whilst aspirations for architecture, veterinary science and arts decreased (Gore et al., 2017). Socio-economic status (SES) was examined by quartiles with those from the highest quartile being more likely to show an interest in science, architecture, medicine, engineering, law and arts, while those students from the other three quartiles were more likely to have aspirations for a career in nursing (Gore et al., 2017). Occupational aspirations by gender were also explored with males more likely to show an interest in engineering whilst females were associated with arts and teaching (Gore et al., 2017). However, in studies relating to educational and occupational aspirations in STEM, many different definitions of STEM have been used.

Numerous attempts have been made to define STEM and what constitutes a STEM occupation or an occupation that requires STEM related skills. Holmes, Gore, Smith and Lloyd (2017) focussed primarily on occupations that require higher level STEM skills often developed through university level studies. Their study used longitudinal data from 2012 to 2015 to investigate the relationships between students' demographic backgrounds, school factors, achievement and career aspirations. Using logistic regression analyses, they found that "being in the older cohorts, possessing high cultural capital, being male, having a parent in a STEM occupation and high prior achievement in reading and numeracy, were significant" (Holmes et al., 2017, p. 655). An intermediate categorisation was used by Won Han (2016) when examining international differences in gender gaps related to STEM occupational expectations, with health and architecture related occupations also included. A broader definition was adopted by the South Australian Department of State Development (DSD) (2015) for analyses and reporting purposes, with building and trade related occupations included. Like many areas of research, the definitions and categorisations of variables used in research must be closely examined to assess levels of influence.

2.5.2. Attitudes towards STEM

A student's attitudes towards STEM, including interest, enjoyment, motivation, perceived difficulty, self-efficacy, self-concept, value and relevance, and anxiety related to STEM subjects, can influence both achievement and subsequent enrolment in STEM. A longitudinal study in the UK assessed students' (aged 15 and 17) attitudes towards mathematics and its relationship to intention and actual enrolment in upper secondary level mathematics and future intention to study mathematics at university (Sheldrake et al., 2015). They found that gender (males more likely), self-concept in mathematics, intrinsic and extrinsic motivation for mathematics, emotional responses to mathematics (e.g. enjoyment, boredom), perception of mathematics teachers and advice/pressure to study mathematics (parent/teacher suggestions and peer choices) were predictive of future intention and actual enrolment in senior secondary mathematics courses and intention to enrol in university level mathematics courses (Sheldrake et al., 2015).

Ainley, Kos and Nicholas (2008) used PISA 2006 data to show that attitudinal constructs such as interest, motivation and aspirations were moderately correlated (coefficients 0.3 to 0.4) with achievement in science, although noting that causality could not be presumed but an interrelation between the two was clear. Köller, Baumert, and Schnabel (2001), in a study conducted in Germany, found that students' interest in mathematics affected both achievement and subsequent enrolment in advanced streams of post-compulsory mathematics. Vidal Rodeiro (2007) showed that students' interest and enjoyment in subjects likely affected their uptake of those subjects in Year 11 and 12, particularly with psychology. A study in NSW by Kennedy et al. (2018) assessed how students' attitudes towards their subjects changed during the first two years of secondary schooling. They found that enjoyability and subject relevance of science was strongly correlated with intentions to pursue science in Years 11 and 12 (Kennedy et al., 2018). Although levels of interest in subjects measured at various points in schooling could influence students' future educational and career decisions, their interest levels in school science and technology tended to decline as they progressed through compulsory schooling (Potvin & Hasni, 2014). The Canadian study by Potvin and Hasni examined the declining levels of interest in science and technology subjects from Year 5 through 11, its comparison with other school subjects (mathematics interest also declined), and potential factors of influence over the varying levels of interest in science and technology (Potvin & Hasni, 2014). It was suggested that the decline in interest in school science and technology was impacted by self-concept and perceived difficulty of the subjects (Potvin & Hasni, 2014). Interestingly, whilst interest in school science and technology declined through the years assessed, interest in out-of-school science and technology and attraction to science and technology careers increased (Potvin & Hasni, 2014).

Motivation for a subject can often be influenced by the perceived difficulty of the subject, self-concept in the subject or the self-efficacy a student has about the subject. Abraham and Barker (2014) showed that sustained engagement (formed by excitement, relevance, enthusiasm and topic reflection) in all four modules of the physics curriculum in NSW was a strong predictor of intention to continue with physics beyond Year 11. It was also reported that students' perceptions of performance (self-efficacy, satisfaction, perception of difficulty and confidence) was the strongest predictor of sustained engagement and subsequent physics enrolment intentions for Year 12 (Abraham & Barker, 2014). Atweh, Taylor and Singh (2005) found that some students were more likely to choose subjects based on their reputation of being easy or requiring less time and effort. In an evaluation of how the formation of attitudes towards science and mathematics can affect subsequent achievement, Else-Quest et al. (2013) found that self-concept was a strong predictor in their sample of 10^{th} grade students in a large north eastern US city (N=367). The study also found that students' perceived value of the subjects and expectations for success were significantly related to achievement in science and mathematics (Else-Quest et al., 2013). Lee (2011) found that students who had higher levels of self-efficacy in mathematics were more likely to enrol in a STEM major in university. Male students with higher levels of self-efficacy in mathematics and female students with higher levels of self-efficacy in science were more likely to choose a STEM major in university than their counterparts (Sahin et al., 2017). In science, girls were found to have lower levels of self-confidence in their scientific ability compared to boys, even after their achievement in science was accounted for (Sikora & Pokropek, 2012a). Conversely, Clyne (2014) argued that anxiety has led females away from selecting post-compulsory mathematics.

2.5.3. STEM and perceived norms

The development of students' perceived norms relating to STEM education and careers is often shaped by their interactions and experiences with parents, teachers, peers and wider society. Dalgety and Coll (2004), using interview data collected from 37 undergraduate chemistry students in a New Zealand university, provided details of the influence that their peers had over their perception of norms related to chemistry related careers, personality traits of chemists and the value of chemists. Being seen to be good at mathematics can carry a certain stigma (Forgasz, 1994) and students may apply social coping strategies to overcome this stigma to gain acceptance (Coleman & Cross, 2005). Public perception of STEM is another possible influencing factor over students' interest and enrolment intentions. Some young people hold a stereotyped view of STEM work, which is often negatively portrayed (Ainley et al., 2008; Clyne, 2014; Engineers Australia, 2007; Henriksen et al., 2015; Lyons & Quinn, 2010). STEM workers are viewed as "hard-working and intelligent, but rather boring and socially awkward" (Bøe et al., 2011, p. 51). Stereotyped images of STEM can be formed through media portrayal and experience students have had whilst in contact with STEM professionals (McIlwee & Robinson, 1992). It might be that students simply do not fully understand what the field of STEM encompasses, the types of activities undertaken and the variety of people that are involved (Lyons & Quinn, 2010; Organisation for Economic Co-operation and Development, 2008). However, many students in DeWitt, Archer and Osborne's (2013) study challenged the previously discussed discourse of a scientist as geeky/nerdy/brainy, suggesting that scientists aren't a particular 'type' of person, simply someone who is interested in the field. The study utilised interviews with students aged 10 or 11 (N=92) and their parents (N=78) about the perceptions they had towards people who engaged highly with science (DeWitt et al., 2013). They found that although students' attitudes towards science were generally positive, this did not translate to students forming a science identity (DeWitt et al., 2013). Throughout interviews, the stereotypical construction of scientists as geeky or nerdy was often cited by parents (DeWitt et al., 2013). Many of those who discussed the construction of scientists in a stereotypical way acknowledged this very fact and sometimes challenged these notions (DeWitt et al., 2013). A science construction that was more frequently discussed by students was the relationship between their peers who were 'into' science also being smart, brainy or clever (DeWitt et al., 2013). Some students and parents described how it takes a particular mindset or genetic makeup to succeed in science, requiring a lot of hard work, dedication and focus (DeWitt et al., 2013). Correlational analyses showed that for a sample of 555 UK students nearing completion of compulsory schooling before entering their final two years of senior secondary schooling (A levels), normative beliefs were strongly associated with an intention to enrol in physics, particularly for perceptions of parents' expectations (Taylor, 2015). The expectations and aspirations of parents can ultimately affect the self-perception of a student's ability and own aspirations. However, the relationship between parental aspirations and expectations and students' own aspirations is complex where:

> children's aspirations and views of science careers are formed within families, and these families play an important, albeit complex, role in shaping the boundaries and nature of what children can conceive of as possible and desirable and the likelihood of their being able to achieve these aspirations (Archer et al., 2012, p. 902)

Archer et al. (2012) described the interplay of social class, family habitus and children's science capital and subsequent aspirations for science careers. They found that when the habitus and capital of middle-class families were aligned with children's identification with science, it led to positive science aspirations (Archer et al., 2012). In contrast, the science capital often displayed within working-class families was less conducive to the development of children's science aspirations (Archer et al., 2012). However, counter examples to both cases existed with children from working-class families going 'against the grain', developing individual aspirations for science, and children from middle class families with high science habitus and capital resisting the push to pursue science (Archer et al., 2012). Lyons and Quinn (2010) also found that students' self-perception of identity influenced their decision about whether to continue participating in post-compulsory science education. They stated that 67% of the cohort of students who did not choose to study a science subject in Year 11 agreed with the statement regarding not being able to picture themselves as a scientist as the reason for non-choice (Lyons & Quinn, 2010). In a longitudinal mixed methods study examining the aspirations of students (Year 3-12) in NSW public schools, parental influences were significant in affecting the career aspirations that their children developed throughout their schooling (Lloyd et al., 2018). Using focus group and survey results where student and parent data matched

(N=1,076), for those students who held STEM career aspirations (N=150), 90% of them had parents who held aspirations for them to complete university degrees (Lloyd et al., 2018). Evidence of parental support and the positive effect it had on students' aspirations was provided by parents in focus groups and reiterated by students in the sample (Lloyd et al., 2018).

2.5.4. Perceived behavioural control over STEM related decisions

Little work has been done on perceived behavioural control specifically in relation to STEM subject choice in senior secondary school. This is likely due to the very nature of the construct and the difficulty of measuring the actual level of perceived behavioural control. As previously outlined, Fishbein and Ajzen (2010) suggested that a person's perception about their control over a decision is an accurate measure of actual control. In this sense, many of the practices of schools relating to streaming would likely impact the perception of control that students have over their subject choice decisions. An issue highlighted by Hogan and Down (2015) was schools pushing some students away from STEM subjects in earlier years of schooling. A process of streaming occurred where students were aligned with either 'academic' or non-academic' educational pathways, meaning large numbers of students disengaged from advanced mathematics and science subjects resulting in declining enrolments in STEM subjects in Year 12 (Hogan & Down, 2015). In a large scale UK study utilising surveys and in-depth longitudinal interviews, it was found that students felt as though they had little actual control over their decisions to study triple science in Year 10 (pathway to entry into three science subjects in Year 11 and 12) (Archer et al., 2017). High performing students were strongly encouraged to enrol in triple science while low-performing students were channelled away, with most feeling like they were making the 'right' decision (Archer et al., 2017). These practices of streaming in and out of 'academically rigorous' science subjects:

> promotes and sustains social inequalities because (1) it functions as a filter for the STEM pipeline (2) it produces symbolic violence, through the association of the Triple Science route with 'cleverness' (3) it creates and reinforces differential cultures on the different routes (e.g. 'excellence' versus 'normality') (4) schools have a differential (inequitable) ability to offer the Triple Science route (Archer et al., 2017, p. 303).

Archer et al. (2017) concluded that the stratification of science subjects in earlier years of schooling (e.g. Year 10) perpetuated students' concepts of science being for 'brainy' students, restricting access to these subjects in Year 11 and 12.

2.5.5. Background factors

2.5.5.1. Gender and STEM

UNESCO reported that only 28% of the world's researchers were women with the disparity occurring due to the "discrimination, biases, social norms and expectations that influence the quality of education they receive and the subjects they study" (United Nations Educational Scientific and Cultural Organization, 2017, p. 5). Gender disparities in STEM participation start as soon as early childhood education and continue to widen as students grow older, with the most dramatic widening during early and late adolescence (United Nations Educational Scientific and Cultural Organization, 2017). Using Australian Bureau of Statistics (ABS) Census data from 2006 and 2011, the Office of the Chief Scientist (2016a) reported that only 29% of Australia's university qualified STEM workforce is female. The under-representation of females studying STEM has been the subject of interest for numerous researchers. However, there is no real clarity in the reasons for this under-representation. Attitudes, gendered curriculum, expectations and discouragement from parents/family, teachers, peers and wider society, identity construction, gender roles, role models and stereotypes are possible influencing factors.

A recent review of the literature that addressed the underrepresentation of women in STEM found three key overarching themes that attempted to explain why there is more profound gender segregation in physics, engineering and computer science compared to biology, chemistry and mathematics (Cheryan, Ziegler, Montoya, & Jiang, 2017). The researchers stated that common findings across the literature were that the masculinised nature of these fields of inquiry resulted in a diminished sense of belonging, insufficient experience in these fields from early ages, and a lack of self-efficacy (Cheryan et al., 2017). A meta-analysis of US based research that examined females' (school aged) participation in STEM education used social identity theory to explain how the social environment (parents, friends, peers and teachers) influenced their engagement with STEM (Kim, Sinatra, & Seyranian, 2018). Much of the literature that was reviewed outlined how "challenging it was for female students to identify with STEM because the social environment provided a variety of signals that women do not belong to STEM and do not embody STEM prototypes" (Kim et al., 2018, p. 601). The lack of a sense of belonging for female students in STEM fields resulted in poor self-efficacy and an inability to perceive future success in STEM (Kim et al., 2018). This was explained as being due to the effect of the STEM environment, with a narrow inclusion criterion classifying females as belonging to the 'in group' or not (Kim et al., 2018). Hassan's (2008) study of Australian students in senior secondary school (Years 10-12) and university found that females had significantly ($p<0.05$) lower levels of self-reported motivation for science, enjoyment of science, lack of anxiety and self-concept of science ability. In a recent study, female students in the first two years of secondary schooling in NSW exhibited lower levels of self-efficacy in science and mathematics (Kennedy et al., 2018). However, this was not the case for attitudes towards technologies, with females reporting higher levels than males (Kennedy et al., 2018).

In terms of gender disparities in the proportions of Australian students enrolling in Mathematics in Year 12, enrolment in advanced mathematics in 2015 was 12.6% for males and 6.9% for females (Barrington & Evans, 2016). This pattern persisted for intermediate mathematics (although not as disparate) with 20.5% for males and 18.0% for females (Barrington & Evans, 2016). Using Longitudinal Surveys of Australian Youth (LSAY) 2003 data, Law (2018) highlighted the gender gap in Australian schools with girls being less likely to enrol in advanced mathematics subjects in Year 12. In an attempt to explain this, multilevel logistic regression modelling was utilised to show that mathematics achievement, occupational expectations for a mathematics intensive career, and self-concept in mathematics at age 15 were predictive of advanced Mathematics subject choice in Year 12 (Law, 2018). Using the same dataset (LSAY 2003) but with a different subsample, Marsh et al. (2019) investigated the gender gap in university STEM course enrolment. In doing this they developed multiple regression models using EVT for STEM subject choice in Year 12 (Marsh et al., 2019). The models presented showed that a gender gap was not present in their Year 12 STEM subject choice models (Marsh et al., 2019), which is a contrasting finding to many previous studies in the field. They found a direct positive effect from gender (females) to STEM subject choice but a negative mediating effect of female students' attitudes towards mathematics and achievement in science and mathematics, resulting in a zero net effect (Marsh et al., 2019). The process Law (2018) used in her research to calculate the outcome variable was quite different to the process used by Marsh et al. (2019). Law (2018) listed all subjects across states and territories within Australia that she categorised as advanced mathematics based on categorisations used by Ainley et al. (2008). Marsh et al. (2019) relied on self-report data based on students' self-perceptions of whether they previously enrolled in a STEM subject in Year 12. They argued that a process similar to Law's (2018) would be too difficult given that categorisation techniques for encompassing a variable that includes all STEM subjects could lead to "potentially intractable problems in classifying many 100s of course titles where the actual content varies from school-to-school and across different school systems" (Marsh et al., 2019, p. 12).

In a review of international literature on girls' participation in STEM from preschool through secondary school combined with interviews of various stakeholders, many factors relating to sociocultural norms and gender bias were shown to have a detrimental effect on girl's STEM engagement (Hobbs et al., 2017). Girls' self-formation of identity, beliefs (self-efficacy) and attitudes related to STEM (predominantly physics and mathematics) were influenced by their interactions with parents, peers, teachers and the wider society (Hobbs et al., 2017). In particular, parents and teachers tended to have lower STEM expectations of girls compared to boys throughout all stages of schooling, which often resulted in career advice in secondary school leading girls' away from STEM fields (Hobbs et al., 2017). Girls were also shown to be provided with fewer opportunities to engage with STEM by parents and teachers beyond the basic activities provided in formal school settings (Hobbs et al., 2017). In physics and mathematics, many topics have been taught through the use of examples of traditionally masculinised applications, producing a gendered curriculum and potentially having a negative influence on girls' interest and subsequent engagement in those subjects (Hobbs et al., 2017). Using a large scale survey of UK students aged 15, Mujtaba and Reiss (2013) examined the differences between girls who intended to study physics post-16 with those who did not. They found that girls who had higher physics extrinsic motivation, perceived the physics classroom (teachers and lessons) positively, were highly competitive and were less extrovert were more likely to intend to study physics post-16 (Mujtaba & Reiss, 2013).

Using Longitudinal Surveys of Australian Youth 2006 data, Sikora (2014b) found that females were less likely to enrol in science related tertiary qualifications than males, while the gender gap in science career aspirations and science enrolment in Year 12 was not as prominent. When a disaggregated approach was taken and a more specific distinction was made between fields, several studies showed that females tended to be associated with enrolment in the health, social and biological sciences whereas males were associated with mathematics, chemical and physical sciences (Bennett & Hogarth, 2009; Bøe et al., 2011; Fullarton & Ainley, 2000; National Academies of Sciences Engineering and Medicine, 2016a; Sikora, 2014a; Sikora & Pokropek, 2012b). Using Programme for International Student Assessment (PISA) 2006 data, Sikora and Pokropek (2012a) found that, across 50 countries, many of them exhibited gender segregation in the science career plans of students aged 15, where "science-oriented girls prefer employment in biology, agriculture, or health (BAH), whereas boys favour careers in computing, engineering, or mathematics (CEM)" (Sikora & Pokropek, 2012a, p. 234). Researchers in the US found that males were more likely to have career aspirations for engineering whereas females were more inclined to pursue health and medicine (Sadler, Sonnert, Hazari, & Tai, 2012). Also shown was the relationship between STEM interest at the beginning of high school and interest at the end of formal schooling, with the decline more prevalent in females (Sadler et al., 2012). In Australia, Sikora (2014b) found gender segregation still existed with males being more likely to have career aspirations and Year 12 enrolment in physical science careers/subjects and females more likely to follow the life science pathways (Sikora, 2014b). The gender segregation gap widened even further when tertiary enrolment in physical science qualifications were considered, with males being five times more likely to enrol in those courses than females (Sikora, 2014b).

In a qualitative study of 18 female students enrolled in Year 11 physics at both public and private schools in a major metropolitan Australian city, researchers found that a combination of school culture, teachers, family, peers and 'self' were influential in their science engagement (Oliver, Woods-McConney, Maor, & McConney, 2017). In particular, academic foci, expectations, level of competitiveness and the status of science within schools contributed to the effect of school culture on their engagement with science (Oliver et al., 2017). For teachers of science, their likability, caring nature, quality of explanation and content knowledge influenced female students' engagement in class (Oliver et al., 2017). The support, guidance and opportunity for engagement in science outside of the classroom from family members (parents, grandparents and siblings) were influential in their attitude towards science (Oliver et al., 2017). Female students who had peers who performed well in science, helped them in class, and made the subject more fun were found to be reasons for sustained engagement in science (Oliver et al., 2017). Finally, individuals' levels of enjoyment, interest, curiosity and self-regulation practices went some way to explaining their level of engagement in the science classroom (Oliver et al., 2017). A US study including 871 girls (ages ranging from 11–18), showed that science and mathematics teacher influence (encouragement and expectations) was a significant positive predictor of interest and confidence in science and mathematics (Heaverlo, 2011). Using data collected from two longitudinal studies in the US over a 20 year period, 27 female participants were identified where their educational and career aspirations during schooling years did not match with their actual pathways, and they were subsequently interviewed (Banerjee, Schenke, Lam, & Eccles, 2018). Women who held STEM career aspirations but did not follow a STEM pathway and women who did not hold STEM aspirations but ended up following a STEM pathway discussed factors that influenced their career decisions (Banerjee et al., 2018). Issues related to consideration for family and work/life balance were instrumental in the decisions of some women to not pursue a career in STEM, a decision many women feel forced to make when considering to have children or not (Banerjee et al., 2018). Previous experiences with teachers in science and mathematics classrooms, including enthusiasm, pedagogy and content knowledge, were highlighted as major influences over their interest, enjoyment and success in STEM (Banerjee et al., 2018). One participant described how she initially had negative experiences with mathematics and low expectations for success, but the positive experience with a teacher who "helped facilitate increased expectations of success in the subject, increased her interest and put mathematics into a more positive light" (Banerjee et al., 2018, p. 298).

In a US study of 1,799 introductory science students in university it was found that the degree to which they subscribed to traditional gendered stereotypes of science (e.g. men more equipped to excel in science than women) was indicative of self-identification with science and future science career aspirations (Cundiff, Vescio, Loken, & Lo, 2013). In particular, women who more strongly subscribed to traditional stereotypes had weaker science identification and subsequent science career aspirations, whilst men who held stronger traditional gendered stereotype beliefs more strongly identified with science and had stronger science career aspirations (Cundiff et al., 2013). A large scale longitudinal survey with UK primary school children aged 10 and 11, along with interviews with 92 children and 78 parents, found a range of identity construction related factors that likely influenced the future science aspirations of young girls (Archer et al., 2013). Although over 70% of survey respondents indicated they enjoyed science, less than 17% of those held science career aspirations (Archer et al., 2013). The study examined more deeply the girls (N=25) in the interview sample who did not hold science career aspirations, finding that science did not fit with either "(1) their constructions of desirable/intelligible femininity or (2) their learner identities and student self-concept" (Archer et al., 2013, p. 8). More specifically, girls who did not hold science aspirations were more inclined towards 'nurturing' or 'glamorous/girly' jobs, falling in line with often cited socially constructed notions of femininity and the contrasting stereotype of science as masculine (Archer et al., 2013). These ideas were echoed by the views of parents who often described science as a masculine field, dominated by males (Archer et al., 2013). Many of the girls who did not aspire to science careers also described those who have passion for science as 'clever/brainy', resulting in an effect where those who experienced lower levels of achievement or had lower self-efficacy independent of actual grades felt like it was 'not for them' or unattainable (Archer et al., 2013). In a follow up study, which focussed on the interview data from both male and female students (N=70) aged 15/16 and their parents (N=62), evidence was provided for existing discourses that exclude those categorised as 'girly girl' based on misogynistic foundations (Francis, Archer, Moote, de Witt, & Yeomans, 2017b). The perception of femininity as a 'lack', and the opposite to hegemonic masculinity, was evident in the interviews, where even positive examples of femininity as caring and nurturing were seen as superficial and examples of 'lack' (Francis et al., 2017b). The concept of hyper femininity, described as 'girly girl' was often constructed as vacuous, where people described as such were seen as having less content to deal with in their lives and as incapable of doing work in physics, involving work that was 'hard' and 'hands on' (Francis et al., 2017b). Cervia and Biancheri

(2017) examined surveys of researchers and academics from the University of Pisa's (Italy) Medicine and Engineering Department, a male- dominated section of the institution. They found that traditionally socially constructed gender roles were present where males would often remain in academia while females would have to support the family by taking on the role of mother and wife/partner (Cervia & Biancheri, 2017). Female academics were predominantly given the role of primary caregiver in the home, taking on the majority of responsibility of duties around the household, detracting from the time and energy commitment male colleagues were typically afforded to dedicate to academia and potential progression in the field (Cervia & Biancheri, 2017). The barriers that women face in STEM fields is also evident in the Australian context. Using panel data from the Household, Income and Labour Dynamics in Australia Surveys 2001 – 2006, Dockery and Bawa (2018) reported that STEM female workers had a lower participation rate, higher unemployment rate, lower real hourly wages (significantly lower than males), and lower satisfaction levels with employment opportunities and overall job satisfaction compared with their female non-STEM counterparts. They suggested that the emphasis of gender equity in STEM should not be focussed solely on increasing female STEM participation, but on the barriers that many women face once they enter the STEM workforce (Dockery & Bawa, 2018).

The lack of female role models in STEM is a possible explanation for their under-representation in the field (Blickenstaff, 2005). Role models within STEM have proven to improve attitudes towards STEM, self-efficacy and interest in a STEM career (Blickenstaff, 2005; McIntyre, Paulson, & Lord, 2003). In an experimental design research study using analyses of variance, researchers showed that women in university performed better on a mathematics test when one of two conditions was met: either women were told they were better at psychology experiments than men, or women were given the chance to read about four female role models in medicine, law, architecture and invention (McIntyre et al., 2003). In a review of the literature (1980s – 2000s) providing potential explanations for the underrepresentation of women in STEM fields, Blickenstaff (2005) described the influence that the lack of female role models has had on young females' attitudes towards and subsequent aspirations for STEM pathways. The simple increase in female role models may not be enough to diminish the apparent gender disparity in many STEM fields, but it is likely to be one part of the solution (Blickenstaff, 2005). However, many of the difficulties female scientists have in promoting positive examples for young people related to the media portrayal of women in science and exacerbated the issues of gender stereotypes and cultural contradictions (Chimba & Kitzinger, 2010).

Stereotypes have a particularly alarming effect on gender roles within STEM. Gender-based stereotypes of a male dominant workplace negatively influence females' interest in pursuing a STEM career (Chimba & Kitzinger, 2010; Francis et al., 2017a). The stereotyped image of science as masculine is particularly evident in the domain of physics, as UK researchers found in their interviews with 15-16 year-olds and their parents (N=132) (Francis et al., 2017a). One of the key findings that participants in the study discussed relating to barriers for women's advancement in physics was the existence of gender discrimination evidenced by "cautionary tales of sexism that female novices had experienced in seeking to access Physics and Engineering" (Francis et al., 2017a, p. 164). The other major finding was the persistent portrayal of physics as 'quintessentially masculine' with five distinct narratives supporting the perception:

> (a) Certain subjects are gender stereotyped as being masculine or feminine (and hence as appropriate for different genders), (b) Men and women are naturally different and drawn to different subjects, (c) Femininity is antithetical to (masculine) manual work, (d) Femininity is superficial, and (e) Cleverness is masculine, and Physics is a clever/difficult subject (Francis et al., 2017a, p. 168).

Using document analyses of media reports in the UK, it was found that depictions of women scientists would often provide great detail about their appearance (hair style, clothing, stature etc.), where depictions of male scientists appearance would often be brief and attend to traditional stereotypes (glasses, beard, 'nerdy' image) (Chimba & Kitzinger, 2010). The authors acknowledged that many of the media reports may have been using this type of language to challenge some of the traditional stereotyped images of the 'boffin' scientist, but negative connotations related to focussing the attention on the appearance of women scientists rather than their expertise could be damaging (Chimba & Kitzinger, 2010). During interviews with female scientists engaged in the study, issues were raised around the use of the qualifying term 'female scientist' rather than simply 'scientist', emphasising "the divide between "real" scientists (senior men who are the traditional source for news journalists and documentary makers) and science “eye-candy” (younger, enthusiastic women)” (Chimba & Kitzinger, 2010, p. 616). There were conflicting notions of providing a ‘human face’ to female scientists, with interviewees describing the inappropriateness of questioning about personal relationships (assuming heterosexuality), whilst wanting to provide enough information about their personal lives to convey the ‘normal’ daily pressures and experiences that all women face (Chimba & Kitzinger, 2010). There were mostly contested notions of media outlets’ focus on femininity or sexuality in science offered by participants, with one stating “I think they do waste a lot of [time] talking about the colour of my lipstick etc, which really isn’t relevant when you are trying to talk about one’s work and be taken seriously” (Chimba & Kitzinger, 2010, p. 618). Another example showed a more neutral perspective, with a participant remarking “I think it is fine to care about how you look and be interested in how the universe works” (Chimba & Kitzinger, 2010, p. 618). Nevertheless, the researchers summarised that “male scientists are still represented as the norm, whereas women are framed as somehow exceptional” (Chimba & Kitzinger, 2010, p. 621), continuing the disparate representation of gender roles within science.

2.5.5.2. Socio-economic status

Socio-economic status (SES) is a potential influencing factor in the uptake of STEM subjects at the senior secondary level (Fullarton & Ainley, 2000; McGaw, 2006; Perry & Southwell, 2014; Vidal Rodeiro, 2007). Fullarton and Ainley (2000) stated that students from high SES backgrounds were twice as likely to enrol in Physics in Year 12 as their low-SES peers. Vidal Rodeiro (2007) reported that “students chose subjects that corresponded closely to their parents’ position in the economic and cultural hierarchy” (p. 6). If a student’s parents had professional careers then they were more likely to choose science or other more traditionally academic subjects (Vidal Rodeiro, 2007).The relationship between social class (SES) and subject choice may have operated through attitudes towards the subjects, with students from high-SES backgrounds more likely to have higher levels of interest in and enjoyment of those subjects (Vidal Rodeiro, 2007). Using PISA 2003 data, McGaw (2006) found that SES may operate as both an individual and a school levels factor rather than solely as an individual one. He found that in Australia 30% of the variation in performance between schools was explained by the overall social background of the school, compared to 40% explained by individual SES (McGaw, 2006). In Western Australia, Perry and Southwell (2014) examined the level of access students from differing backgrounds had to academic curriculum. They found that "students who attend low-SES schools have substantially less access to academic curriculum than do students in other schools" (Perry & Southwell, 2014, p. 481), limiting their ability to apply for university entry. Variation was also found in the breadth and depth of course offerings between school sectors (public vs private) (Perry & Southwell, 2014), adding to the inequity debate in relation to Australian schooling.

2.5.5.3. Ethnicity and immigrant status

Ethnicity is another demographic variable that may influence STEM uptake in school. Measures of ethnicity commonly include the language most often spoken at home and immigrant status (participant birthplace and parents' birthplace). Fullarton and Ainley (2000) found that "students whose parents were born in a non-English speaking country were more likely to study mathematics… and … physical sciences" (2000, p. 19). In Vidal Rodeiro's (2007) large scale UK study, it was found that 'non-white' students (self-identified) were more likely to choose science or practical subjects than their 'white' peers. In the US, Else-Quest, Mineo and Higgins (2013) examined how the intersection of gender and ethnicity affected 10th grade students' attitudes towards and achievement in science and mathematics. They found that although there was no discernible difference in grades between males and females at the end of the year, Asian American students outperformed students from other ethnic groups (White, African American and Latino/Latina) (Else-Quest et al., 2013). In a related finding, Sahin, Ekmekci and Waxman (2017) reported that Asian American students were more likely than their non-Asian American counterparts to choose a STEM major in university. Museus et al. (2011) discussed the extent of the ethnic minority disparities that are present in the US and found a number of factors at different stages of life that affected the STEM educational and career pathways of members of these ethnic minority communities. During K-12, school funding, teacher quality and encouragement, academic tracking, culturally relevant curricula, STEM career exposure, dispositions towards STEM and academic preparedness all contributed to entrance into STEM majors in university (Museus et al., 2011). The progression of students from ethnic minority groups through STEM majors in university was influenced by parental expectations and involvement, finances, campus climate, STEM opportunity and support programs, in turn affecting university outcomes such as dispositions towards STEM, academic performance and STEM degree completion (Museus et al., 2011). In a US study that investigated the effect of the intersectionality of gender, ethnicity and SES on aspirations for STEM careers, stark aspirational gaps were found (Saw et al., 2018). It was reported that 17.9% of white male students who came from a high SES background had STEM career aspirations at the beginning of high school, whilst black female students reported much lower aspirational levels (1.8%) (Saw et al., 2018). The gap between white male students from high SES backgrounds continued to widen throughout high school compared to females from all combinations of SES and ethnicity (Saw et al., 2018). Australian research by Marjoribanks (2005) on educational attainment and aspirations found that young adults from various ethnic backgrounds were influenced by their families' social status (SES) in different ways. In particular, Asian women's attainment levels were unaffected by SES, where Anglo Australian and Middle Eastern women were affected by their families' SES (Marjoribanks, 2005).

2.5.5.4. Peer enrolment and achievement

Peers influence the decision-making process of students' enrolment intentions (Dalgety & Coll, 2004; Gemici et al., 2014; Lyons & Quinn, 2010; Marsh et al., 2008; Nagengast & Marsh, 2012; Palmer, 2015; Wang & Degol, 2013). In Wang and Degol's (2013) research, students' mathematics achievement and enrolment decisions were positively affected by and consistent with those of their peers. Students' aspirations towards higher education and career pathways can be significantly influenced by peers; "students whose friends plan to attend university are nearly four times more likely to plan to attend university" (Gemici et al., 2014, p. 3). A secondary analysis of PISA 2006 data using multilevel SEM found that although individual prior science achievement had a positive effect on students' science self-concept and science career aspirations, higher levels of class average and school average science achievement had a negative effect on individual science self-concept and science career aspirations (Nagengast & Marsh, 2012). This phenomena is known as "the big-fish-little-pond-effect", where high achieving students in schools (or classrooms) with high achievement levels tend to have lower levels of academic self-concept than their equally able counterparts in average or low achieving schools (or classrooms) (Marsh et al., 2008). "The big-fish-little-pond-effect" often applies in schools with academic streaming practices where students are placed in low/average/high achieving classes, often in mathematics. Those students who are more competent in the low achievement groups develop higher levels of academic self-concept, due to the variability of peer achievement within the classroom (Nagengast & Marsh, 2012). Some students in the high achievement classes start to question their own ability or achievement and show lower levels of academic self-concept due to the highly competitive nature of the classroom (Nagengast & Marsh, 2012).

2.5.5.5. ATAR requirements and university pre-requisites

In Australia, participation in STEM subjects in senior secondary school has long been seen as a requirement for various higher education pathways. All subjects across Australia undergo a process of scaling (South Australian Tertiary Admission Centre, 2016), and whether a subject is scaled up or down does not technically depend upon the difficulty of the subject, however, there tends to be a positive correlation between the two (DUX College, 2016). Therefore, STEM subjects such as Chemistry, Mathematical Methods, Specialist Mathematics and Physics tend to be scaled up (Victorian Tertiary Admission Centre, 2013). However, drawing on NSW high school certificate (HSC) data and information related to ATAR calculations, Pitt (2015) used results from a standardised mathematics test completed in Year 10 to form expected scores for students in future HSC mathematics exams that would contribute to their ATAR. He found that students who enrolled in the 'general' mathematics course were more likely to be scaled higher (relative to past performance) in the HSC mathematics exams than those students who enrolled in the 'higher level' HSC mathematics subject. Pitt (2015) explained that while not all students would benefit from taking the General Mathematics course over the advanced course, many students could benefit from such a strategy due to the current ATAR score algorithm used. Mathematics coordinators in WA schools were surveyed about the declining enrolment in senior secondary mathematics courses, and cited various reasons for students not undertaking higher level mathematics (Hine, 2018). Hine (2018) found that higher level mathematics "courses are not required for university entrance, other courses appear to be less rigorous and more viable, and the Australian Tertiary Admissions Ranking (ATAR) score can be maximised by taking one mathematics course instead of two courses" (p. 635). Still, many university courses including engineering, medicine, dentistry, pharmacy, and various science related degrees have at least one STEM subject as a pre-requisite (South Australian Tertiary Admission Centre, 2015). This adds utility value to STEM subjects as it leaves students' options open for a variety of courses (Bøe et al., 2011). Lyons and Quinn (2010) have suggested that students often undergo a process of weighing up each subject's utility value against its relative cost value. Students essentially rank each potential subject based on perceived level of effort, time, attainment, inclusion as university course pre-requisites and ATAR scaling tendencies (Lyons & Quinn, 2010). However, the number of high level STEM subjects used as pre-requisites for university entry into many courses has recently reduced, lessening the need for students to choose these subjects in Year 12 (Innovation and Science Australia, 2017; Lyons & Quinn, 2010). Atweh et al. (2005) found that a student's decision to keep options open by choosing STEM subjects was sometimes made because the student had no set aspirations for future study or work. Even those students who may have had particular post school goals in mind stated that using the strategy of 'keeping your options open' allowed for "contingencies resulting from a change in aspirations at a later time" (Atweh et al., 2005, p. 14). From 1992 to 2010:

> the proportion of year 12 students in biology fell from 35 to 24 percent, in physics from 21 to 14 percent. This period coincided with a broadening of the range of secondary subjects and a reduction in the role of prerequisites for university entrance into science-based programs, creating greater scope for student choice (Marginson, Tytler, Freeman, & Roberts, 2013, p. 16)

A report released by the Australian Council of Learned Academies (ACOLA) in 2013 suggested that there were three main factors that had resulted in the decline of STEM enrolment in Years 11 and 12 in Australia (Marginson et al., 2013). The authors of the report described how the non-compulsion aspect of Australian schools along with:

> the increased range of choices in Australian schooling, the reduced role of science and mathematics prerequisites in university entrance (and the corresponding greater emphasis on score level rather than content preparation), and thus the ease of opting out of harder STEM subjects, are associated with both the deterioration in the proportion of the student cohort taking STEM subjects and the deterioration in the proportion of students doing the most challenging subjects (Marginson et al., 2013, p. 81).

Marginson et al. (2013) used the case of Japan to describe the dramatic impact that reducing the level of compulsion for particular subjects can have on enrolment patterns and achievement of students in standardised testing in mathematics and science. They explained how Japanese students with university aspirations had been required to undertake chemistry, biology, earth science and physics until the end of schooling (Marginson et al., 2013). In 1982 this level of compulsion was reduced to enrolling in two of these subjects, whilst university requirements also decreased (Marginson et al., 2013). Further school curriculum changes in 1998 resulted in a 30% decrease in content for science and mathematics subjects, not only decreasing students' motivation for STEM but diminishing enrolment numbers in physics from 90% (1970s) to 20% (2000s) (Marginson et al., 2013). Clearly, a broadening of the curriculum, removal of STEM pre-requisites and a 'softening' of curriculum had a negative effect on STEM enrolments in schools.

2.5.5.6. School context

Various school-level factors influence senior secondary subject choice. School sector (Government/Catholic/Independent), school gender (single-sex/co-educational), location (metro/non-metro), and school-size are factors that have been widely reported as influences on STEM participation in the senior secondary years. Fullarton and Ainley (2000) found that students from independent schools were 1.5 times more likely to enrol in physical sciences. Fullarton et al. (2003) supported this position reporting that the rate of participation in advanced mathematics and physical sciences was higher in the independent sector, which could potentially also be an individual SES factor and a school-level SES factor. Using LSAY 2009 data, Sikora (2014a) described how basic analyses showed that girls in an all-girls school were more likely to enrol in physics subjects in Year 12 and have career aspirations for physical sciences, engineering or computing compared to their counterparts in co-educational schools. However, when various other influential factors were controlled for (achievement, study time, self-concept, family background and availability of quality teachers) the effect diminished (Sikora, 2014a). Only marginal differences remained after accounting for control variables, where boys in all-boys schools were more likely to have life science career aspirations and girls in all-girls schools were less likely to have life science career aspirations (Sikora, 2014a). In the UK, larger schools were more likely to have students completing chemistry, physics and mathematics, although this was possibly due to a wider range of subjects being available (Spielhofer et al., 2002), and this combination of subjects was more likely to occur in single-sex schools compared to co-educational schools. An issue that has been highlighted, particularly in smaller schools, is the range of subject choices. Vidal Rodeiro (2007) found:

> Sometimes students had to choose subjects not on the basis of their preferred course, but on whether or not the school offered it. In a few cases, students had to compromise on their choices in order to stay on in the same school. In other cases, students changed centres in order to study a particular subject. Around 16% of the students in this research reported that they attended a different centre to have access to their preferred subjects (p. 6).

A school's decision to offer subjects such as physics, chemistry and advanced mathematics had a direct influence on participation rates in these subjects (Smyth & Hannan, 2006). Using PISA 2006 data for Czech Republic, Germany, Finland and Norway cohorts, Basl (2011) showed through linear regression and structural equation modelling analyses that a school's ability to prepare students for future education and careers positively influenced their future science career aspirations. In a US study using data from multiple nationally collected datasets including information for over 22,000 middle and high school students, two key school related factors were shown to have a strong impact on the gender gap of students' STEM education aspirations (Legewie & DiPrete, 2014). The number and quality of advanced level STEM subject offerings in high school was a positive predictor of students' plans to major in STEM fields at university (Legewie & DiPrete, 2014). Higher levels of gender segregation in relation to extra-curricular activities (membership in sporting and other clubs) was a negative predictor of students' plans to major in STEM fields at university, even after various pre-high school variables (gender, race, SES, occupational aspirations, achievement, interest/usefulness/extracurricular engagement in mathematics and science, STEM orientation, student-teacher ratio and school location/size/type) were controlled for (Legewie & DiPrete, 2014).

In Australia, the Australian Curriculum, Assessment and Reporting Authority (ACARA) has developed national curriculum for Foundation Years through Year 12. However, curriculum is only mandated nationally through to Year 10, with individual state and territory curriculum authorities in control of subjects for Year 11 and 12. In South Australia, students work towards completing the South Australian Certificate of Education (SACE). In 2006, a Ministerial review into senior secondary education was undertaken with a number of recommendations handed down (Government of South Australia, 2006). The Ministerial review resulted in the introduction of the ‘New SACE’, which was developed and implemented over a four-year period with the first full year undertaken in 2011. Following the first full attempt at implementing the ‘New SACE’ in 2011, an independent evaluation was commissioned by the SACE board of South Australia. Authors of the independent evaluation suggested that with the introduction of the ‘New SACE’, the content of curriculum was relatively unchanged but there were significant changes to the SACE completion requirements (Cossey, Bennett, Silva, & Lietz, 2012). The completion requirements were changed so that 20 credits (two semester topics) fewer than previously needed to be completed with:

> literacy and numeracy being essential at Stage 1 rather than the former SACE pattern at Stage 2, a compulsory Research Project at Stage 2 instead of a fifth subject and a Personal Learning Plan at Stage 1 (normally completed in Year 10) (Cossey et al., 2012, p. 4).

Essentially, students were required to undertake and obtain a ‘C’ grade in at least one semester (10 credits) of a mathematics subject and two semesters (20 credits) of an English subject at Stage 1 and the research project subject (10 credits) at Stage 2 in order to satisfy the requirements to complete the South Australian Certificate of Education (SACE Board of South Australia, 2018). Stage 1 subjects are typically undertaken in Year 11 and Stage 2 subjects undertaken in Year 12, but this is not always the case. Prior to the introduction of the ‘New SACE’, students would usually enrol in four Year 12 subjects to gain their SACE or five subjects if they intended to gain acceptance into a university course (Cossey et al., 2012). In many schools, the introduction of the research project essentially replaced the fifth Year 12 subject, with many students undertaking 3 subjects plus the research project, or 4 subjects and the research project if university bound (Cossey et al., 2012). The notion of students likely undertaking one less Year 12 subject provides a simple explanation for the decrease in enrolments in STEM subjects over the last decade. One of the recommendations of Cossey et al. (2012) was to remove the research project from being a compulsory Stage 2 subject for SACE completion, instead moving it to being a Stage 1 subject (without ATAR implications), and the option of studying it as a full-year subject at Stage 2. Actions were not taken by the SACE Board based on this recommendation until recently, and then in a partial way. In 2017, the compulsory 10 credit Stage 2 research project was included as a tertiary admission subject resulting in its availability for ATAR calculations. Also, the SACE Board developed a new non-compulsory 10 credit Stage 1 research practices topic to help prepare students for the Stage 2 research project. More recently, the Government of South Australia (2018) released a report which reviewed the Year 12 SACE structure. The authors of the report recommended a similar strategy to the one suggested by the 2012 Cossey et al. report, where the research project would become a compulsory Stage 1 (10 credit) subject with the option of studying an extra 20 credit research project at Stage 2 (Government of South Australia, 2018). Should the change to the completion requirements of the SACE at Stage 2 come in to effect, the recommendation is for students to undertake five Stage 2 subjects (20 credit) or any combination of 10 and 20 credit Stage 2 subjects (Government of South Australia, 2018). A further recommendation which would alter the likelihood of students undertaking more STEM subjects in senior secondary school is that equal weighting be given to literacy and numeracy requirements, particularly if the decision is made to increase its size to a 20 credit Stage 1 subject for English and mathematics (Government of South Australia, 2018). Changes based on these recommendations have not been reflected in the SACE completion requirements at this current stage. Recently, the SACE Board of South Australia (2019) released a response to the review, summarising the recommendations made. Professor Martin Westwell (Chief Executive of the SACE Board of South Australia) has suggested via email that “there will be no immediate action from the SACE board” (personal communication, June 3, 2019) as the implementation of the recommendations is “subject to financial support from the State Government” (SACE Board of South Australia, 2019, p. 1).

Prior research has shown that restricting the flexibility of subject choice may be useful. Marginson et al. (2013) argued that the simplest solution to increasing STEM enrolment in senior secondary school would be to make some combination of mathematics and/or science compulsory to Year 11 and potentially to Year 12. Strengthening the compulsion of STEM subjects would reduce student choice, shifting the focus to improving the quality of curriculum and instruction of STEM subjects in senior secondary school (Marginson et al., 2013). However, they stressed the importance of training and recruiting more suitably qualified teachers with science degrees (including mathematics) to be teaching these courses at the Year 11 and 12 levels if they were to be mandated (Marginson et al., 2013). The compulsion of subjects to higher levels does come at a cost, which Marginson et al. (2013) argued cannot be taken lightly. The reduced flexibility of students' choice would likely disengage them from other non-STEM subjects that may be of benefit to their educational skill development (Marginson et al., 2013). Further discussion between all state and territory curriculum authorities, subject associations, universities and other relevant organisations could prove a useful forum to engage in reform talks (Marginson et al., 2013). A number of strategies could provide useful talking points including compulsion of mathematics (of varying levels) up to Year 11 (or 12), compulsion of at least one science subject up to Year 11 (or 12), and an increase in the number and level of pre-requisites for university entry to subjects requiring STEM specific skills (Marginson et al., 2013).

2.5.5.7. Prior achievement in STEM

Prior achievement in STEM subjects, particularly mathematics, influences subsequent enrolment (Ainley et al., 2008; Fullarton & Ainley, 2000; Gill & Bell, 2013; Lee, 2011; Vidal Rodeiro, 2007). Fullarton and Ainley (2000) suggested that previous levels of literacy and numeracy influence STEM participation, where students who "achieve at the highest level of literacy are more than three times as likely to study either physics or chemistry, and students in the highest numeracy quartile are more than eight times as likely to study these subjects" (p. 23). Vidal Rodeiro (2007) found that prior achievement was predictive of enrolment in traditional subjects such as mathematics, English, sciences (physics, chemistry and biology), history, languages, geography and music. However, the trend was reversed for newer/vocational subjects such as media, art, sociology, psychology, computing and business studies (Vidal Rodeiro, 2007). A study by Lee (2011) in the US showed through multilevel SEM that students with higher levels of prior achievement in mathematics were positively associated with enrolment in a STEM major in university. In Australia, prior achievement in mathematics was strongly associated with enrolment in chemistry and Physics in Year 12 (Ainley et al., 2008). Further, in 2004–2006 students from the highest mathematics achievement quartile were 11 times more likely to enrol in chemistry and 15 times more likely to enrol in physics than their peers in the lowest mathematics achievement quartile (Ainley et al., 2008).

2.5.5.8. STEM teacher quality

The role of teachers in influencing students' enrolment decisions has been reported in many studies. Activities used (Bennett & Hogarth, 2009), teacher support (De Loof et al., 2017) and reputation (Atweh et al., 2005) have all been shown to influence enrolment intentions. In Bennett and Hogarth's (2009) research, students aged 11, 14 and 16 showed mostly favourable attitudes towards activities (60%, 54% and 44% agreement respectively) completed in science lessons making them more interested in science. In a Belgian study examining students and teachers of mathematics, physics and integrated STEM, questionnaires and classroom observations were used to assess the effect of STEM teachers' motivating styles on students' collective engagement (De Loof et al., 2017). Through multiple linear regression and multivariate analysis of variance techniques, teachers' autonomy support, structure and involvement was found to influence students' levels of collective engagement (De Loof et al., 2017). The level of autonomy support and classroom structure of STEM teachers was also influential in students' reported levels of self-determined motivation (De Loof et al., 2017). The reputation a teacher had amongst the student cohort or students' prior experiences in their classes influenced whether students enrolled in their subjects in later years, where they "avoided subjects taught by teachers who they did not like, and chose subjects that were taught by teachers who are known to be student-friendly" (Atweh et al., 2005, p. 14). The issue of STEM teachers in the Australian workforce who are teaching 'out-of-field' was addressed by Weldon (2016) using data from the 2013 Staff in Australia's Schools (SiAS) survey. If teaching out-of-field is classified as not having studied the subject area to second year tertiary level and not having undertaken a teaching methodology subject in that area, then 38% of mathematics teachers (Years 7-10) were found to be teaching out-of-field (Weldon, 2016). Also, approximately 45% of physics teachers, 37% of chemistry teachers and 58% of information technology teachers were classified as teaching out-of-field (Weldon, 2016). Perplexingly, Weldon (2016) reported that a significant proportion of the suitably qualified mathematics (15%), physics (25%), chemistry (36%) and information technology (28%) teacher workforce who were surveyed were not currently teaching those subjects for a variety of reasons. Although the solution to this problem may seem obvious, that is to recruit and train more STEM teachers, the process to attract more suitably qualified STEM teachers into schools is complex. One potential solution in the immediate future is for schools to recognise that many STEM teachers are teaching out-of-field and to support them by making professional development around STEM curriculum and pedagogy a priority. Irrespective of the experience and qualifications of teachers within STEM classes across all year levels in schools, if they are provided with "sustained discipline-specific professional development programs, focused on pedagogical content knowledge and content knowledge that are not part of generic professional development programs common to all teachers" (Marginson et al., 2013, p. 118) then the quality of STEM education within the school will likely improve. Professional development initiatives would also benefit from the inclusion of discussion around the use of inquiry based activities and problem solving that enhance the use of critical and creative thinking (Marginson et al., 2013).

2.5.5.9. STEM exposure outside of the classroom

In the US, out-of-school STEM programs are now commonplace, becoming "a focal piece of the education opportunities provided by many national non-profit organizations, state-wide education networks, federal programs, and corporate and family foundations" (National Research Council, 2015). Student involvement in these STEM learning opportunities outside of the classroom directly influenced their experience and attitude towards STEM in the school setting, including interest in and understanding of STEM, and connection with role models, and improved the achievement level of low SES students (National Research Council, 2015). Out-of-school STEM programs that have been found to be most effective provided students with hands-on experiences, inquiry based learning opportunities, and made connections to their personal everyday lives (National Research Council, 2015). Out-of-school STEM programs have traditionally been less common in Australia. However, with the recent focus on STEM education being emphasised by national and state governments funding of strategies and initiatives to improve the state of STEM learning and teaching, more integrated and multidisciplinary STEM programs are being offered. A list of STEM programmes offered throughout Australia (SPI 2016) was compiled by the Office of the Chief Scientist (2016b) in consultation with the Ai Group, including in-school (excursions, mentoring, school visits, career expos, university enrichment), after-school (clubs and holiday programs) and out-of-school experiences for primary and secondary aged students. A substantial list of these types of programmes and resources was also provided for subject specific (general science, biology, earth science, physics, digital technology and ICT, engineering, and mathematics) domains. Many of the programmes available were either in-school or organised through schools. Those that were classified as integrated STEM or multidisciplinary included 23 in-school programmes, seven after-school or holiday programmes, eight mentoring/school visits/careers programmes, seven competitions, four excursion programmes, 14 university enrichment programs and two residential programs. Only one programme was classified as out-of-school whilst there were three that simply provided integrated STEM and multidisciplinary resources. An adequate level of possibilities to engage in out-of-school STEM programmes is missing in the Australian context.

Exposure to STEM activities at home can also provide a platform to increase students' attitudes towards and aspiration for STEM. In a study examining the effect of parental involvement and investment on students' scientific achievement and self-efficacy using Hong Kong 2006 PISA data, Ho (2010) found a positive relationship. Multilevel analyses via hierarchical linear modelling showed that if students had access to more cultural resources they had higher levels of achievement and self-efficacy in science, whilst more access to educational and material resources positively affected students' self-efficacy in science (Ho, 2010). The level of science activities prepared at home at age 10 was a positive influence on students' achievement and self-efficacy in science (Ho, 2010). Conversely, parents' level of communication with the school and participation in school activities had a significant negative influence on students' self-efficacy in science (Ho, 2010).

2.5.6. Factors that influence STEM subject choice: a summary

In summary, a number of factors that are in line with the TPB as the guiding conceptual framework have previously been shown to influence the STEM educational decisions of students at various levels of education. A student's educational and career aspirations for STEM are often seen as a proxy for an intention to enrol in future STEM and pursue STEM career pathways. A number of attitudinal constructs such as interest, enjoyment, motivation, perceived difficulty, self-efficacy, self-concept, and value placed on STEM have also been shown to influence aspirations and subsequent STEM subject choice. Interactions with parents, peers, teachers and wider society have previously been shown to influence students' perceived norms as they relate to engagement with STEM learning. A number of school related variables influence the level of control that students have over their STEM educational decisions. A number of background factors such as gender, SES, immigrant status, peer groups, ATAR scaling and university pre-requisites, school context (sector, gender, location and size), prior achievement, teacher quality, and exposure to STEM outside of the classroom have previously been reported to influence students' STEM enrolment decisions.

2.6. Gaps in research

The apparent STEM skills shortage as indicated by workforce demands and a changing global economy justifies research on student choice of STEM subjects in Year 12. However, hard evidence of the suggested STEM skills shortage and a common description of what constitutes a STEM subject must first be sought. Further, the literature review has highlighted the complexity of STEM subject choice in senior secondary school. Several studies have attempted to investigate subject choice behaviour in this context, but there is much variation in approaches, descriptions and definitions used in research. It may seem that there is sufficient research in this field; however, several previous studies were narrow in the scope of their investigations. A broader approach investigating a wide range of potential factors influencing STEM subject choice is justified (Department of Further Education Employment Science and Technology, 2011; Straffon, 2011; Wang, 2012). Limited research has been identified that focusses on Year 12 STEM as a whole subject choice. No research has been located that investigates factors related to STEM subject choice in Year 12 in South Australia. At the time of the study, integrated STEM subjects were not common in Year 12 studies in schools throughout Australia. Therefore, the remainder of this thesis and the research presented throughout focuses on the assemblage of individual STEM subjects classified as relating to science, technology, engineering and mathematics. Specific Year 12 subjects in each Australian state and territory classified as STEM in this research are outlined in Chapter 3. The complexity of a student's decision-making process demands a deeper understanding of the influencing factors (Organisation for Economic Co-operation and Development, 2006a; Wang & Degol, 2013; Wang, 2012). The use of qualitative inquiry or mixed methods approaches has been suggested as a potential solution in forming a deeper understanding of the decision-making process influencing subject choice (Rowan-Kenyon et al., 2012; Tytler & Osborne, 2012). More specifically, understanding the barriers and facilitators that influence STEM participation is critical (Wang, 2012).

2.7. Research questions

A review of the literature and identified gaps in the field of STEM education resulted in the following Research Questions:

Research Question 1

- What factors (student and school) influence students' STEM enrolment decisions in Year 12?

Research Question 2

- How do background variables influence students' beliefs about STEM, intention towards STEM and enrolment in STEM subjects in Year 12?

2.8. Summary

International and national literature on the importance of STEM related skills, particularly in the technologically advancing workforce and globalised economy, have been outlined in this review. Consideration of the workforce demand and economic needs related to developing more STEM literate citizens has been addressed. STEM education policy and the requirement of education systems and processes to respond to the changing nature of society were highlighted. Through the use of the TPB as the guiding conceptual framework many factors of potential influence were presented and discussed as they related to the intentions, attitudes, perceived norms, perceived behavioural control and background factors of students and their decisions of whether or not to pursue STEM education in senior secondary school and beyond. The literature review and identified gaps within the literature emphasised the importance of gaining a better understanding of the process by which students make their post-compulsory educational enrolment decisions.

3. METHODOLOGY

3.1. Introduction

Variation in the STEM subject enrolment decisions of students entering Year 12 in Australia has highlighted the need to investigate this complex and important phenomena, as shown in Chapter 2. The overarching worldview of pragmatism adopted for this research suggests that mixed methods research be undertaken to address the complex and multi-faceted issue related to underlying decision making, particularly in this context. The quantitative methods presented in this chapter describe how data from the Programme for International Student Assessment (PISA) and the Longitudinal Surveys of Australian Youth (LSAY) were used to identify the student and school factors that influence STEM subject choice in Year 12. The qualitative methods described in this chapter outline how the researcher attempted to explain the process students undergo when making enrolment decisions in Year 12. Integration methods combining both quantitative and qualitative results are explained to provide a well-rounded picture of the decision-making processes of students entering Year 12. To the best of my knowledge and based on the literature reviewed in Chapter 2, this level of research combining multiple methods of analysis using multiple sources of data in the context presented in this thesis has not previously been conducted.

3.2. Theoretical perspective

This study was undertaken with a pragmatist worldview. Although there is contention about the definition of a worldview, it can be seen as a “general philosophical orientation about the world and the nature of research that a researcher brings to a study” (Creswell, 2014, p. 6). Pragmatism emerged from the writings of Peirce, Dewey, James, Mead (Punch, 2009), and more recently Rorty (Hall, 2013). According to Pring (2015), pragmatism allows the researcher to satisfy “the practical problems for the time being…it helps one to face new situations” (Pring, 2015, p. 161). A pragmatist is concerned only with questions that have a practical solution (Pring, 2015). Greater importance is placed on the research questions and attention is paid to these prior to choosing methods to employ or worldviews to be adopted (Punch, 2014). It makes the research questions the primary focus of the study, influencing the decision about the most appropriate methods to use in addressing the questions (Lamont & Swidler, 2014; Mackenzie & Knipe, 2006; Punch, 2014; Punch & Oancea, 2014). Pragmatism does not rely on one ontological or epistemological idea of reality, thus allowing the researcher to choose freely the most appropriate method and tools to address each research question (Creswell, 2014). Pragmatists place an emphasis on behaviours, beliefs about and likely consequences of those behaviours (Morgan, 2007). Research in social science is always viewed with consideration for the “social, historical, political, and other contexts” (Cherryholmes, 1992, p. 14) that the individuals are placed within. Pragmatists do not see the world as a concept of absolute unity and are more concerned with how they can improve the situation (Creswell, 2014).. Research findings are viewed as potentially transferrable, where the results in one particular context could be applied in other situations with varying degrees of generalisability (Morgan, 2007). This is in opposition to traditional worldviews that view research findings as either context specific (qualitative) or universally applicable (quantitative) (Morgan, 2007). The adoption of a pragmatic approach is not simply to identify the lens through which the social phenomenon is examined, rather to concentrate on “beliefs that are more directly connected to actions” (Morgan, 2014, p. 1051). In Cherryholmes’ (1992) notes on pragmatism and scientific realism, he concluded his review with the following: “Do not block the road to inquiry, and look to the consequences” (p. 16). In relation to the use of the theory of planned behaviour (TPB) as the conceptual framework guiding the study, Cooper, Barkatsas and Strathdee (2016) argued that “a pragmatist paradigm is typically an effective methodological approach to use with the TPB” (p. 145).

3.3. Methodological design

The adoption of a pragmatist worldview resulted in the necessity to utilise a mixed methods approach in addressing the Research Questions posed in this study, as outlined and justified in Section 3.3.1. Following this, more specific details are provided about the consideration given to both quantitative and qualitative research in Sections 3.3.2 and 3.3.3. Methodological decisions that were made as a result of the nature of the differing types of inquiry are provided throughout these sections.

3.3.1. Mixed methods

With the overarching worldview of pragmatism which presumes methodological pluralism (Johnson & Onwuegbuzie, 2004; Lamont & Swidler, 2014), a mixed methods approach was taken. Pragmatism recognises the need for multiple assumptions, methods of data collection and analyses which is consistent with mixed methods (Creswell, 2014). Simply put, mixed methods research is any "empirical research that involves the collection and analysis of both qualitative and quantitative data" (Punch, 2014, p. 302). The research questions in this study are varied in nature and required both approaches to best address them. The research design employed in this study attempted to account for the weaknesses of each method on its own and combined the findings to gain a deeper understanding of the phenomenon (Creswell & Plano Clark, 2011). The pragmatic approach to mixed methods research required abduction in connecting theory with data through a sequential design of both quantitative and qualitative methods (Morgan, 2007). Therefore, this study employed an explanatory sequential design (Creswell, 2005, 2014) conducted in two phases, with a quantitative phase followed by a qualitative phase. This approach was used as the researcher wished to build upon and explain the preliminary quantitative findings in a more in-depth manner (Punch, 2009). The quantitative results explain relationships between student and school level variables but do not provide the "more detailed understanding of what the statistical tests or effect sizes actually mean" (Creswell & Plano Clark, 2011, p. 9). The qualitative data help to further develop a complex understanding of the phenomena.

The following purposes for mixing methods was outlined by Greene (2007) derived from Greene, Caracelli and Graham (1989). The analysis and results from the quantitative phase informed the development of the qualitative phase. The qualitative phase attempted to expand the breadth and range of the research to gain a deeper understanding of the problem, utilising different methods for each inquiry component. The results from both phases underwent a process of complementarity, where the qualitative phase elaborated on and sought clarification for the findings from the quantitative phase.

It is important to outline that even though there are distinct differences between quantitative and qualitative research, the similarities between them are present and help to validate their consideration for appearing alongside each other in research design. Hardy and Bryman (2004, pp. 4-9) outlined the following similarities of the two research approaches:

- Both are concerned with data reduction;
- Both are concerned with answering research questions;
- Both are concerned with relating data analysis to the research literature;
- Both are concerned with variation;
- Both can treat frequency as a springboard for analysis;
- Both seek to ensure that deliberate distortion does not occur;
- Both argue the importance of transparency; and
- Both must address the question of error.

3.3.2. Quantitative research

Quantitative research is often addressed with a post-positivist worldview which is aligned with scientific inquiry (Creswell, 2014). The quantitative phase was approached with a postpositivist lens including the ontological and epistemological assumptions that informed it. Postposivitism seeks to find causality between variables and to test, verify and refine theories (Creswell, 2014). Quantitative research grounds the concept of reality in terms of variables, measures them and examines the relationships between these variables (Punch, 2014). In examining the relationships between these variables it then seeks to replicate findings and is generalisable (Creswell, 2014). Quantitative research is concerned with understanding the objective reality of a phenomenon by studying the behaviour of individuals (Creswell, 2014).

The fundamental underlying assumptions of postpositivism, taken from Creswell (2014) and Phillips and Burbules (2000) are:

- Knowledge is conjectural;
- Existing theories are tested;
- Researchers accept, reject or refine those theories based on results;
- Knowledge is shaped by "data, evidence and rational considerations" (Creswell, 2014, p. 7);
- Relevant statements are developed that attempt to explain relationships between variables;
- Objective approach to inquiry;
- Importance placed on ensuring validity and reliability; and
- Potential bias explored.

Being objective and controlling for bias are fundamental to the postposivitist approach, contributing to the validity and reliability of results (Bryman, 2008; Creswell, 2014).

3.3.3. Qualitative research

The qualitative phase required an interpretivist lens. Interpretivism "requires the social scientist to grasp the subjective meaning of social action" (Bryman, 2008, p. 16). As the social reality of human beings is meaningful, influenced by the actions and views of others, interpretivists attempt to grasp meaning based on these assumptions (Bryman, 2008). The subjective meanings constructed by the participant are shaped by their social, cultural and historical experiences as well as by those of the researcher (Creswell, 2014). Qualitative researchers address phenomena by attempting to understand how individuals are placed within a context, influenced by "symbols, social structures, social roles, and so forth" (Berg, 2009, p. 8). The method of analysis suggested by Moustakas (1994) then directs the researcher to break the text into manageable chunks (where there is a shift in meaning), write a general description for each chunk, and then develop an overall psychologically meaningful structure in order to interpret the data. As the researcher intended to gain an in-depth understanding into the phenomenon, aspects of case study methodology were applied (Punch, 2009; Yin, 2014). A case study has the following features: investigates a phenomenon within a real world context, engages multiple sources of evidence with integration of results, and utilises a pre-existing theoretical framework to guide methodological procedures (Yin, 2014). It allowed the researcher to investigate the social, emotional, motivational, experiential and behavioural background of individuals (Berg, 2009). The case study approach enabled the researcher to gather information on the participants, those who chose a STEM subject in Year 12 and those who did not, and to understand how the decision-making process operates or functions (Berg, 2009). A comparative case study uses multiple sources of information from multiple individual cases to gain a greater understanding of a collective group (Berg, 2009).. Yin (2014) suggested that a multiple case study design is a more robust approach than single case study designs.

3.4. Quantitative methods

A series of more specific Data Questions that were developed as a result of Research Question 1 was addressed using quantitative research methods, as outlined in Section 3.4.1. Methods of data collection and data analysis for the quantitative phase of the research are presented in Sections 3.4.2 and 3.4.3.

3.4.1. Data questions

In order to address Research Question 1 (What factors (student and school) influence students' STEM enrolment decisions in Year 12?) a number of specific data questions were developed. The first two data questions investigated the student factors that influenced their enrolment decisions in Year 12:

Data Question 1

- What student factors directly influence Year 12 STEM student enrolment decisions?

Data Question 2

- What student factors mediate the relationship between Year 12 students' demographic background and STEM subject choice?

Data question three drives an investigation into the ways in which school-related factors influence relationships between student characteristics and their observed STEM enrolment behaviours in Year 12:

Data Question 3

- What school level factors moderate the relationships between Year 12 students' demographic characteristics and STEM subject choice?

3.4.2. Data collection

The first research question and subsequent data questions (1-3) were explored using quantitative methods. This phase of the research utilised secondary data. Secondary data analysis is defined as "any inquiry based on the re-analysis of previously analysed research data" (Jary & Jary, 2000, p. 540). It can include large-scale data sets that yield far larger samples than one could obtain individually with limited time and resources (Vartanian, 2011). There are various advantages to using secondary data sets. They are less costly and less difficult to organise, allow for advanced modelling techniques to be applied, are pre-programmed and coded, and are often of high quality, having been collected by reputable research organisations (Vartanian, 2011). The secondary datasets used in this study provided access to a large number of variables from a large sample likely to be representative of the population, allowing for advanced statistical techniques to be applied (Vartanian, 2011).

Since the focus for this study was on the factors that influence students' decisions to choose, or not choose, STEM subjects, secondary data from the Programme for International Student Assessment (PISA) (Organisation for Economic Co-operation and Development, 2006b) and the Longitudinal Surveys of Australian Youth (LSAY) (National Centre for Vocational Education Research, 2006-2009) were analysed, offering access to extensive information covering a broad range of students and schools. PISA has been administered every three years since 2000 and has a particular focus for each year: the focus in 2000 and 2009 was reading, for 2003 and 2012 it was mathematics, and 2006 and 2015 it was science. The breadth of data collected allowed for analyses investigating the relationship between school level factors and individual level factors such as gender, SES, immigrant status and achievement (Organisation for Economic Co-operation and Development, 2014). The 2006 PISA cohort was the focus for this research as it emphasised attitudes towards science. More current PISA/LSAY data (e.g. PISA 2015), that included items relating to attitude towards science and Year 12 subject enrolment, was not available at the time of the study.

PISA utilises a two-stage stratified sample design, with the first stage using systematic probability proportional to size sampling to select schools, and the second phase using simple random sampling within selected schools to sample students (Organisation for Economic Co-operation and Development, 2014). As a consequence of the rigorous sampling design and the expertise deployed in generating questionnaire and test items, the PISA data were extensive and of very high quality. However, some students may have been over- or under-represented (e.g. all indigenous students were invited from selected schools) along with schools of varying sizes. Student weights and school cluster information were used to account for this under- or over- sampling. Data were collected with strict quality assurance policies which included field trials, survey reviews, optical checks and quality monitor consultations (Organisation for Economic Co-operation and Development, 2014).

LSAY is a longitudinal survey that since 2003 has been based on the Australian PISA sample whereby all Australian PISA participants are invited to take part, and that follows their progression over about a 10 year period (National Centre for Vocational Education Research, 2016e). Some of the topics explored in LSAY were attitudes and enrolment in schools, post school pathways, career pathways and issues of equity (National Centre for Vocational Education Research, 2016a). NCVER (National Centre for Vocational Education Research) (2016d) have strict protocols in place for LSAY data to ensure privacy and confidentiality, control the release of information, and employ data restrictions. The quality of LSAY data is ensured due to the resolution of data queries, data output automation, data cross-checking and the release of detailed documentation (National Centre for Vocational Education Research, 2016b). Items in LSAY (Waves 2, 3 and 4) allowed the researcher to ascertain students' subject enrolment in their senior year of high school. Due to attrition, participant response rates fell from

14,170 (Wave 1 – Initial PISA sample) to 7,299 (Wave 4) (National Centre for Vocational Education Research, 2016c). The total number of students included in the dataset (taken from LSAY Waves 2, 3 and 4) was 7,442. The total number of schools from which students were sampled was 353.

3.4.3. Data analysis

Basic descriptive analysis was first undertaken followed by multiple regression modelling, structural equation modelling (SEM), multilevel multiple regression modelling and multilevel SEM. Initial exploration of data involved preliminary checking of PISA and LSAY datasets for issues related to normality, multi collinearity, linearity assumption, outliers and missing data. As a result of the initial exploration of data, multiple imputed datasets were produced to account for missing data. Following this, single (student) level multiple regression models were developed using software Hierarchical Linear Modelling (HLM) version 7 (Raudenbush, Bryk, & Congdon, 2013). Single (student) level SEMs were then developed using Mplus version 7.4 (Muthén & Muthén, 1998-2012). In order to analyse the interaction of variables, SEMs with a series of direct and indirect (mediating) paths were tested. Models with different outcome variables (STEM subject choice, Physics subject choice and Biology subject choice) were developed. A model for Mathematics subject choice is not presented due to the attitudinal constructs used in the model focussing on science. As the outcomes of interest are binary, models using logistic and probit regression were developed. Data questions relating to Research Question 1 were answered through the use of both single (student) level and multilevel modelling. The hierarchical nature of the data (students sampled from within participating schools) indicated that multilevel models were necessary, with the dependent variable at the lowest level followed by explanatory variables at various other levels (Hox, 1995). Both multilevel multiple regression models (in HLM) and multilevel SEMs (in Mplus) examining STEM subject choice were developed as a result. In this case, student level variables were at Level 1 and school level variables (including aggregated student information) were at Level 2. An outline of the quantitative data analysis plan highlighting the methods used to address all quantitative data questions can be seen in Table 3-1. An electronic copy of information related to both input (syntax) and output (results) of all models presented in this thesis are available upon request.

Further elaboration of methods discussed here are explained in more detail in the subsequent sections.

Table 3-1

Quantitative data analysis plan

		Student level STEM subject choice regression model (HLM)	Student level STEM subject choice SEM (Mplus)	Student level Physics subject choice SEM (Mplus)	Student level Biology subject choice SEM (Mplus)	Multilevel STEM subject choice regression model (HLM)	Multilevel STEM subject choice SEM (Mplus)
Data Question 1	What student factors directly influence Year 12 STEM student enrolment decisions?	x	x	x	x		
Data Question 2	What student factors mediate the relationships between Year 12 students' demographic backgrounds and STEM subject choice?	x	x	x	x		
Data Question 3	What school level factors influence the relationships between Year 12 students' demographic characteristics, attitudes towards science, achievement in science and mathematics, and STEM subject choice?					x	x

3.4.3.1. Data preparation

Variables used in the quantitative phase of the study can be categorised as either student level variables or school level variables. A list of the student level (Table 3-2) and school level (Table 3-3) variables and their definitions are provided below.

Table 3-2

Student level variables used in the study

Variable	Definition
Female	The variable 'female' is dichotomous, represents gender, and has been coded 0 for males and 1 for females.
SES	SES is a scale variable developed by PISA (labelled ESCS) and is derived from items relating to possessions in the home, number of books in the home, highest status of parental occupation and education. This provides a relative value of socio-economic status for each student.
Native	The variable 'native' has been dichotomised from the PISA variable immigrant status and has been coded 0 for non-native students and 1 for native students. A native student is someone who had at least one parent who was born in Australia.
Personal Value of Science	'Personal value in science' is a scale variable developed by PISA and is derived from five items related to students' perceptions of the personal value of science e.g. ST18Q08: I find that science helps me to understand the things around me.
Enjoyment of Science	'Enjoyment of science' is a scale variable developed by PISA and is derived from four items e.g. ST16Q01: I generally have fun when I am learning science topics.
Self-Concept in Science	'Self-concept in science' is a scale variable developed by PISA and is derived from six items related to students' self-perception of ability in science e.g. ST37Q06: I can easily understand new ideas in school science.
Achievement in Science	The latent variable 'achievement in science' is a first order factor derived from five items, namely 'plausible value in science 1-5'. The plausible values are "multiple imputations of the unobserved latent achievement for each student" (Wu, 2005, p. 114). These values "represent the range of abilities a student might reasonably have, given the student's item responses" (Wu, 2005, p. 115).
Achievement in Mathematics	Similarly, the latent variable 'achievement in mathematics' is a first order factor derived from five items, namely 'plausible value in mathematics 1-5'.
Achievement in Science and Mathematics	The latent variable 'achievement in science and mathematics' is a second order factor derived from the latent variables 'achievement in science' and 'achievement in mathematics'. This provides a composite score that reflects what each student's ability may be in relation to science and mathematics.
Achievement in Science and Mathematics (Mod)	The variable 'achievement in science and mathematics (mod)' is an alternative computation to the achievement in science and mathematics variable used in student level SEMs. It has been computed from the mean of both 'plausible value in science 1' and 'plausible value in mathematics 1'. This variable was used for all regression models in HLM. This variable was also used in the multilevel SEM in Mplus, with multiple imputation analyses used to account for plausible values 2-5.
STEM Subject Choice	The variable 'STEM subject choice' has been dichotomised from a STEM count variable and has been coded 0 for no STEM subjects selected and 1 for at least one STEM subject selected. The STEM count variable was derived from information from the LSAY dataset regarding choice of subjects in the final year of high school (Year 12). The list of subjects that have been classified as STEM can be seen in Table 3-4. Subject selection criteria are discussed in more detail in Section 3.4.3.1.1.
Physics subject choice	The variable 'Physics subject choice' has been dichotomised from a physics count variable and has been coded 0 for no physics subjects selected and 1 for at least one physics subject selected. The physics count variable was derived from information from the LSAY dataset. The subjects that have been classified as physics are Physics and Physics (inc. Electronics).
Biology subject choice	The variable 'Biology subject choice' has been dichotomised from a biology count variable and has been coded 0 for no biology subjects selected and 1 for at least one biology subject selected. The biology count variable was derived from information from the LSAY dataset. The subjects that have been classified as biology are Biology and Human Biology.

Table 3-3

School level variables used in the study

Variable	Definition
Metropolitan School	The variable 'metropolitan school' is a dichotomous variable coded 0 for rural and remote schools and 1 for metropolitan schools.
Ratio - Native	The variable 'ratio - native' is a scale variable that has been created in Mplus by computing the cluster mean of the native variable for students within each school in the dataset. This represents the proportion of native students for each school.
Ratio - Female	The variable 'ratio - female' is a scale variable that has been created in Mplus by computing the cluster mean of the female variable for students within each school in the dataset. This represents the proportion of female students for each school.
Average - SES	The variable 'average - SES is a scale variable that has been created in Mplus by computing the cluster mean of the SES variable for students within each school in the dataset. This represents the average SES for each school.

3.4.3.1.1. STEM subject selection criteria

Decisions relating to the subjects included in the STEM categorisation for all states and territories was based on work by previous researchers and the author's predefined criteria. Subjects that are likely to lead to a STEM university pathway and a subsequent technical/professional STEM pathway were designated as STEM for this study. That is, only relatively high-level mathematics, science and technology subjects were included as STEM subjects. Examples of those subjects that were included are Mathematical Methods and Specialist Mathematics while those that have been excluded were Mathematical Applications and General Mathematics. Mathematics subjects classified as STEM were drawn from Barrington and Brown's (2005) advanced and intermediate categorisation, where included subjects would typically lead to tertiary studies that require significant or extensive mathematical preparation. Science subject labels varied greatly from state to state and the list outlined in Ainley, Kos and Nicholas (2008) was used. Technology encompasses a diverse suite of subjects and ranges from subjects such as food and hospitality and design and technology (likely to lead to vocational education) to information technology (likely to lead to tertiary education). Subjects from the technology section were only included if they were defined as information technology, computer/software design or engineering related. Perceived level of complexity and technical aspects involved in the topics were used in the decision-making process. Subjects were only included if they were likely to lead to a university pathway. Examples of those subjects that were included are Information Technology, Software Design and Development, and Engineering Studies, while examples of those that were excluded are Information Processing and Publishing, Business Communication and Technologies, and Design and Technology. The suite of subjects included in the STEM categorisation for PISA/LSAY 2006 can be seen in Table 3-4.

Table 3-4

STEM s*ubjects used in the study*

STEM Area	Year 12 Subject	State/Territory*
Science	Agricultural Science	2,4
	Biology	1,2,3,4,5,6,7,8
	Chemistry	1,2,3,4,5,6,7,8
	Earth and Environmental Science	2,6
	Earth Science	1,4
	Environmental Science	3,7
	Geology	8
	Human Biology	6,8
	Marine and Aquatic Practices	4
	Marine Studies	4
	Physics	1,2,3,4,5,6,7,8
	Physics (inc. Electronics)	1,2
	Psychology	1,3,5,8
Technology	Advanced Electronics	7
	Aeronautics	6
	Computer Graphics and Design	7
	Computer Science	6,7
	Computing Applications	2
	Design and Technology - Systems & Control Products	5,8
	Design Graphics	7
	Electrotechnology	3
	Graphics	1,2,4,8
	Information and Communication Technology	4,8
	Information Processes and Technology	2
	Information Processing and Technology	2,4,6,8
	Information Studies	1
	Information Systems	7

Table 3-4 *Cont.*

STEM Area	Year 12 Subject	State/Territory*
	Information Technology	5,8
	Information Technology Systems	1,3,4,5
	Introduction to Electronics	7
	IT- Applications (3 & 4)	3
	IT- Information Processing & Management	3
	Software Design and Development	1,2
	Software Development	3
	Systems Engineering	3
	Systems Technology	6
	Technology Studies	4
Engineering	Engineering	6
	Engineering Studies	1,2
	Engineering Technology	1,4
Mathematics	Calculus	6
	Mathematical Methods	1,4,5,8
	Mathematical Methods (Computer Algebra Systems)	3,8
	Mathematical Methods (Units 1 & 2 or 3 & 4)	3,5
	Mathematical Studies	5,8
	Mathematics	1,2,5,7,8
	Mathematics B	2,3,4,6
	Mathematics C	1,3,4
	Mathematics Extension (inc. 1 & 2)	1,2,7
	Mathematics Methods	7
	Mathematics Specialised	7
	Specialist Mathematics	1,5,8
	Specialist Mathematics (Units 3 & 4)	1,3

Note. * 1 – ACT, 2 – NSW, 3 – VIC, 4 – QLD, 5 – SA, 6 – WA, 7 – TAS, 8 – NT.

3.4.3.1.2. Data cleaning and checking

A series of steps were undertaken to ensure that the data were adequately cleaned and prepared for analyses. Tests for normality were undertaken for all scale variables included in the models. A visual assessment of histograms and P-P plots for distributions following guidelines outlined by Field (2013, pp. 179-181) was undertaken. A numerical assessment of normality was conducted with all skewness (-0.253 to 0.164) and kurtosis (-0.243 to 0.263) values falling within the accepted range of -2 to 2 (George & Mallery, 2016). A missing data analysis was performed to analyse patterns of missing values to assess whether any variables had responses that were missing at random (MAR), missing completely at random (MCAR) or not missing at random (NMAR) (Little & Rubin, 1987). None of the variables of interest were NMAR, allowing for them to be used in subsequent analyses. In PISA/LSAY 2006 the percentage of missing values varied from zero (complete data) to 17.4% missing. In order to account for the missing data, multiple imputation as described by Rubin (1987) was undertaken. Based on a Monte Carlo simulation study by Graham, Olchowski and Gilreath (2007) 20 imputations was deemed sufficient for the level of missing values to ensure adequate power. Maximum Likelihood (ML) estimation (with expectation-maximization algorithm) (Rubin, 1987) using fully conditional specification with the Markov Chain Monte Carlo method was used in IBM SPSS 23.0 (IBM Corp., Released 2015). All demographic and attitudinal variables of interest were used in the imputation process with those with complete data used only as predictors.

Multi collinearity between independent variables was tested using linear regression and collinearity diagnostics in IBM SPSS 23.0 (IBM Corp., Released 2015). A general rule of thumb is that variation inflation factor (VIF) values >5 warrant further investigation and values >10 should be removed from analyses or combined to produce a new variable (Kline, 2016). All VIF values in PISA/LSAY 2006 were <4. The outlier labelling rule, as described by Hoaglin and Iglewicz (1987), was used to identify outliers for scale variables used in the analyses. The criterion value of k=2.2 is used to determine if any responses fall far enough outside the upper and lower quartiles to be considered as 'extreme' and potential outliers (Hoaglin & Iglewicz, 1987). Of the 7,442 students included, three responses were identified as potential outliers for SES, four for self-concept in science, one for plausible value in mathematics, and four for plausible value in science. However, all responses were checked to ensure that the calculation of these variables was done correctly. It was deemed that these responses were not erroneous and they remained in the dataset for all subsequent analyses. An assessment of correlation coefficients (Table 3-5) and scatterplots between pairs of scale variables was undertaken to ensure that the linearity assumption was upheld.

Table 3-5

Correlations between continuous covariates (Pooled)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. SES														
2. PerValSc	.146**													
3. EnjoySc	.150**	.693**												
4. SlfConSc	.165**	.577**	.678**											
5. PVMaths1	.295**	.327**	.396**	.414**										
6. PVMaths2	.294**	.325**	.391**	.412**	.859**									
7. PVMaths3	.298**	.330**	.392**	.413**	.861**	.863**								
8. PVMaths4	.297**	.327**	.393**	.411**	.859**	.862**	.863**							
9. PVMaths5	.290**	.321**	.388**	.405**	.862**	.860**	.864**	.863**						
10. PVSci1	.295**	.346**	.421**	.437**	.870**	.811**	.817**	.815**	.812**					
11. PVSci2	.299**	.352**	.425**	.439**	.817**	.870**	.819**	.817**	.817**	.902**				
12. PVSci3	.298**	.348**	.423**	.440**	.812**	.813**	.867**	.812**	.814**	.901**	.900**			
13. PVSci4	.300**	.351**	.429**	.439**	.813**	.807**	.815**	.867**	.811**	.899**	.896**	.897**		
14. PVSci5	.292**	.348**	.426**	.436**	.817**	.810**	.818**	.819**	.870**	.898**	.897**	.899**	.898**	
Mean	0.345	0.163	0.098	0.021	27.224	27.231	27.239	27.228	27.249	27.787	27.821	27.788	27.787	27.826
SD	0.744	1.065	0.998	0.979	4.049	4.041	4.027	4.044	4.037	4.588	4.565	4.593	4.569	4.606

Note. ** Correlation is significant at 0.01 level.

3.4.3.2. Model Estimation

PISA utilised a two-stage stratified sampling design where schools were first selected based on enrolment numbers and various other characteristics like location and sector, followed by the second stage where students were selected. As students were selected to participate in PISA with an unequal probability (some students with disabilities or English language deficiencies were excluded, all indigenous students were included), sampling weights were calculated by PISA to account for this (Lim, 2011). For subsequent LSAY Waves, the same process of weighting for students was adopted and further attrition weights were calculated to account for students from the original PISA cohort dropping out (Lim, 2011). Final weights for each student were then calculated that incorporated information from both sample and attrition weights. More specifically, normalised weights were used to ensure that there was no "mis-specification of standard errors, significance tests and other relevant parameters" (Lim, 2011, p. 19). Students in the final cohort completed one or more of their Year 12 subjects in different years, meaning that their subject selection information was drawn from different LSAY Waves. Only one weight variable could be applied, so the final normalised weight from Wave 2 (2007) was used. Using Wave 2 ensured that all students from the cohort used for analyses would have been included in the computation of final normalised weights.

3.4.3.2.1. Student level analyses

Initial exploration of the relationship between subject choice and demographic background, attitude towards science, and achievement in science and mathematics was undertaken for the PISA 2006 dataset using correlational analysis. This allowed the researcher to investigate the relationship between pairs of variables by assessing the covariance between them (Field, 2013). Student level and multilevel multiple regression models using HLM (Raudenbush et al., 2013) were constructed to further explore potentially influencing factors. Due to the hierarchical structure of the data, i.e. students within schools, multilevel models allowed for each level to have a regression equation. This allowed the researcher to specify how "variables at one level influence relations occurring at another" (Raudenbush & Bryk, 2002). As multiple regression models developed in HLM were exploratory, aiding in the construction of subsequent SEMs, only the first imputed dataset (full sample) for PISA/LSAY 2006 was used in the estimations. Multiple estimation techniques were explored for all student level multiple regression models developed in this research. Rodriquez and Goldman's (1995) simulation study showed that standard estimating procedures used in software packages, such as penalised quasi-likelihood estimation in HLM, can produce biased estimates for models with binary outcomes with low member numbers in clusters. Therefore, full maximum likelihood estimation with numerical integration via adaptive Gaussian quadrature was used, as it was likely to lead to near unbiased estimates (Pinheiro & Bates, 1995). The number of quadrature points of integration can be specified by the user and is likely to affect the level of estimate accuracy. A general strategy is to estimate multiple models of increasing number of quadrature points to see when improvement is no longer substantial. In a simulation study, Pinheiro and Chao (2006) showed that 5 quadrature points is likely sufficient using a binary outcome variable. In this research, initial student level multiple regression models were tested using both 5 and 10 quadrature points. As there was no significant difference in regression and variance estimates between them, 5 quadrature points was chosen for all subsequent models to improve computational efficiency.

After these models were confirmed, SEMs were developed using computer software Mplus (Muthén & Muthén, 1998-2012) to investigate the relationships between potentially influential covariates identified in the multiple regression models. SEM allows for exploration of the covariance between variables by allowing the researcher to understand patterns between them (Kline, 2016). The general goal of SEM is to explain as much of the variance of an outcome variable within the model as possible (Kline, 2016). SEM allows for multiple regression equations to be simultaneously estimated whilst investigating mediation and moderation effects on different outcomes (Wu & Little, 2011). The structure of the path models were derived from the guiding conceptual framework, the TPB, and prior research findings. Random sub samples (15%) of the first imputed datasets were used to produce adequately fitting and parsimonious models. The smaller sub sample datasets would likely not yield significant results for small effects. This allowed the researcher to identify variables of non-significance and minor influence to be excluded from the extended model estimation for full sample imputed datasets. The models that were extended to the full sample imputed datasets, with only those variables included that were significant using the 15% sample, generated robust estimates of significance aggregated across the entire set of data. In student level SEMs there was a combination of categorical and continuous (attitudinal, achievement) predictor, and categorical (binary) outcome variables. Therefore, a robust weighted least squares estimator using a diagonal weight matrix (WLSMV) was used (Muthén & Muthén, 1998-2012). WLSMV estimation produced linear regression coefficients for continuous variables and probit regression coefficients for binary outcome variables. Model estimation using WLSMV improved computational speed (Muthén & Muthén, 1998-2012) and produced traditional fit statistics, whereas ML would not using Mplus. Muthén, du Toit and Spisic (1997) verify the usefulness of weighted least squares estimation for general SEMs with binary outcome variables, performing well statistically and producing good standard error estimates. Weighted least squares and ML estimation are asymptotically equivalent when the model holds (Agresti, 2003). Plausible values for achievement in science and mathematics were scaled down by a factor of 20 so that residual variance fell within the range of 1–10, ensuring convergence. As students are clustered within schools, the cluster option under the variable statement in Mplus was used to account for this.

3.4.3.2.2. School level analyses

Multilevel regression analyses investigating school effects on the student level models were estimated using full maximum likelihood estimation with numerical integration via adaptive Gaussian quadrature, as was done in the student level regression models. Multilevel SEMs were estimated using ML estimation with logistic regression as Type=TwoLevel with numerical integration was required in Mplus (Muthén & Muthén, 1998-2012). More specifically, the maximum likelihood with robust standard errors (MLR) estimator used in this analyses is "known not only to be robust to non-normality but also to allow for MLV (multilevel) analyses based on unbalanced groups" (Byrne, 2012, p. 349). As there were more than 3 dimensions of integration, standard integration with 10 integration points per dimension was used (Muthén & Muthén, 1998-2012). To account for the unbalanced groups on the between level (schools as clusters), a " trimmed school-base weight adjusted for non-response" (Organisation for Economic Co-operation and Development, 2009, p. 370) was used in the estimation process.

The technique of centring was used to give scale covariates in the multilevel model a meaningful zero point where a natural one did not already exist. All school level covariates were centred around the grand mean, as “each member of a given cluster shares the same value on the Level 2 predictor” (Enders & Tofighi, 2007, p. 121). The focus of the multilevel model was to examine cross-level interactions to assess the moderating influence of school level variables on the relationship between demographic background and STEM subject choice in Year 12. Scale covariates at the student level (level one) were group (cluster) mean centred as it:

> “yields a pure estimate of the moderating influence that a Level 2 predictor exerts on the Level 1 association between X and Y and cannot be distorted by the presence of an interaction that involves the cluster means of X” (Enders & Tofighi, 2007, p. 133).

The alternative option was grand mean centring. This option was not used because a significant finding could be shown using grand mean centring in a cross level interaction model even if an interaction was not present in the dataset (Hofmann & Gavin, 1998). As group mean centring was used, the group (cluster) means were included in the model as level two variables (Field, 2013).

3.4.3.3. Model Building

The three goals of model generation are to produce a model which “makes theoretical sense, … is reasonably parsimonious, and … has acceptably close correspondence to the data” (Kline, 2016, p. 11). The model building process used in this research for developing regression models in HLM followed the general guiding principles outlined in Woltman, Feldstain, Mackay and Rocchi (2012). This resulted in five models:

1. Null (unconstrained) model;
2. Random intercepts model (Demographic);
3. Random intercepts model (Demographic and Attitudinal);
4. Random intercepts model (Demographic, Attitudinal and achievement); and
5. Random slopes model (School level variables moderating student level relationships).

These models of increasing complexity were tested and compared for how well they fit the data and how well they help to explain the phenomena of interest. Model building for SEM models explored in this research employed the basic steps of SEM as described by Kline (2016, pp. 118-121):

1. Specify the model;
    a. Initial hypotheses represented as a diagram/set of equations;
    b. List of potential alternative models based on theory;
2. Evaluate model identification;
    a. Can each model parameter be theoretically derived by a unique estimate;
3. Select measures, collect/prepare/screen data;
4. Estimate the model;
    a. Evaluate model fit (if poor, step 5);
    b. Interpret parameter estimates;
        i. Likely need to re-specify;
    c. Consider equivalent/near equivalent models (following this, go to step 6);
        i. Argue why your model better explains data than equivalent/near equivalent models;
5. Re-specify the model (return to step 4);
    a. Decisions made based on theory; and
6. Report the results.

The initial models were developed using previous research findings and the TPB conceptual model. Demographic variables lead to subject choice with attitudinal and achievement measures acting as mediating variables. For multilevel models, school level variables were included at the second level to test for moderating (cross-level interaction) effects. A conceptual model can be seen in Figure 3-1.

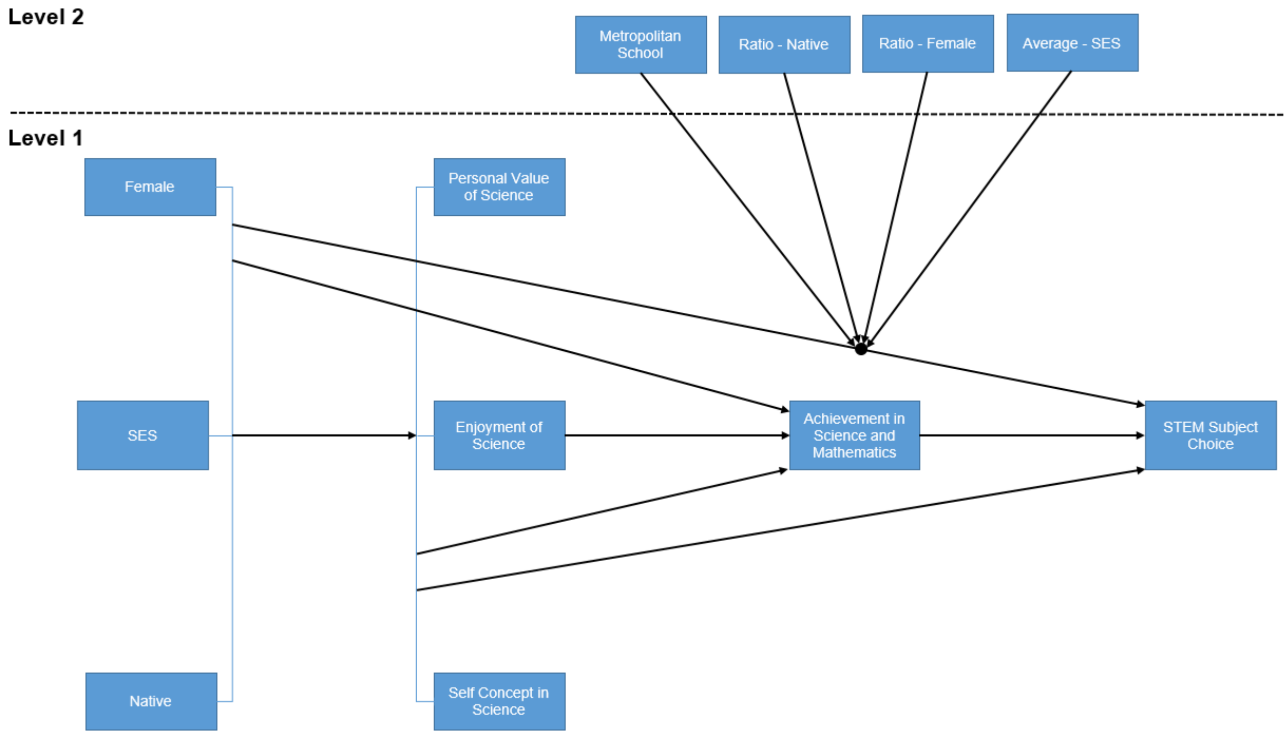

Figure 3-1. Conceptual SEM.

A 15% sample (N=1,129) of the first imputed dataset was used during the model building process. Using the full cohort may have produced estimates that were statistically significant without necessarily being practically important (Kaplan, Chambers, & Glasgow, 2014). Variables of interest were included in the initial model with paths included that were consistent with theory. These included demographic characteristics (gender, SES and immigrant status), attitudes towards science (personal value, enjoyment, self-concept, motivation and self-efficacy), achievement (plausible value in science and mathematics 1-5), and STEM subject choice in Year 12. A series of re-specifications was undertaken with the combination of statistically and theoretically driven decisions made to ensure that the most parsimonious model was reached with adequate explanatory power. Non-significant (at 0.05 level) standardised path estimates and modification indices were used to aid in the re-specification process. However, these decisions were only made if they could be justified on theoretical grounds. In this process variables representing motivation for science and self-efficacy in science were not retained in the model due to non-significance and small regression estimates between them and demographic, achievement and outcome variables. In order to assess the direct effects of demographic background on subject choice, direct paths were retained whether they were significant or not. Once the final model was produced and validated using the smaller sample, the model was extended to the full cohort (N=7,442) and run on all imputed datasets. Parameter estimates from the imputation runs were then aggregated.

3.4.3.4. Model Fit and Validation

In order to ensure that models were deemed appropriate, a process of assessing model fit and model validation was undertaken. In regression models developed using HLM software, deviance (-2 log likelihood) was used to assess how well each model of increasing complexity fit the data and improved explanatory power. The deviance statistic is used to test the fit of nested models as it is "an incremental fit indicator, by which its values are only meaningful relative to the values obtained from other models" (Anderson, 2012). As deviance is a statistic of misfit, larger values represent poorer fitting models. For student level SEMs, root mean square error of approximation (RMSEA), confirmatory fit index (CFI) and Tucker Lewis index (TLI) were used to indicate whether a model had good fit to the data. RMSEA values are a measure of model misfit and "depends only on the fit of the hypothesized model but decrease as goodness of fit improves and attain their lower bound of zero when the model fits perfectly" (Browne, MacCallum, Kim, Andersen, & Glaser, 2002, p. 3). CFI is a normed index (values ranging from zero to one) with values close to one indicating a well-fitting model (Byrne, 2012). TLI is a non-normed index (values ranging from zero to beyond one) with values close to one indicating a well-fitting model (Byrne, 2012). Both CFI and TLI "measure the proportionate improvement in model fit by comparing the hypothesized model in which structure is imposed with the less restricted nested baseline model" (Byrne, 2012, p. 70). The following guidelines were followed to test the adequacy of the fit of the model to the data: RMSEA values <0.05 (Browne & Cudeck, 1992), CFI values >0.95 (Hu & Bentler, 1999) and TLI values >0.95 (Hu & Bentler, 1999) indicated good model fit. Chi-square statistics are provided but they are not used to assess model fit as models may fail a chi-square test purely due to the large sample size (Kline, 2016). For multilevel models Akaike information criterion (AIC) and Bayesian information criterion (BIC) values were used as the models were non-nested (Byrne, 2012; Schreiber, Nora, Stage, Barlow, & King, 2006) and multilevel analyses in Mplus do not produce traditional fit statistics. The

AIC and BIC "take into account model fit (as per the χ2 value) as well as the complexity of the model (as per model degrees of freedom or number of estimated parameters)" (Byrne, 2012, p. 72). Once a final model (using 15% sample) was deemed parsimonious with adequate explanatory power and acceptable fit statistics, a process of model validation was undertaken (Byrne, 2012; Kline, 2016). Model validation involved examining the appropriateness of the final models by testing the equivalence of the causal structure using cross-validation analysis (Byrne, 2012). Byrne's (2012) strategy of "testing invariance across calibration and validation samples" (p. 261) was conducted. This involved randomly splitting the 15% sample dataset into approximately equal size datasets to form the calibration and validation datasets for comparison and invariance testing. This process was followed by a consideration of theoretically equivalent models. Statistically similar models were tested by replacing each attitudinal variable with a theoretically similar one. Alternative models were evaluated, assessing model fit along with a chi square difference test as outlined by Byrne (2012). The model fits for all near equivalent models were inferior to that of the presented models. As previously mentioned for SEMs, once models reached adequate fit using the 15% sample of the first imputed dataset, the models were extended to the full cohort and aggregated across imputed datasets.

3.4.3.5. Data question 1 & 2: Year 12 subject choice – student factors

Findings from previous research and initial exploration of the career aspirations of students within the PISA datasets at age 15 provided an indication of the potential influencing factors on subject choice at Year 12. Subjects defined to be STEM from the PISA/LSAY datasets were combined to produce a binary "STEM subject choice in Year 12" variable. Initially, computer software HLM (Raudenbush et al., 2013) was used to test a student level multiple regression model for STEM subject choice in Year 12 with PISA/LSAY 2006 data, addressing Data Question 1. An iterative process of testing alternative models of increasing complexity starting with the null model, then adding demographic, attitudinal and achievement variables was undertaken using logistic regression with ML estimation. Following the establishment of a multiple regression model using HLM, a SEM was developed in Mplus (Muthén & Muthén, 1998-2012) which attempted to explain the underlying factors relating to a student's decision of whether or not to enrol in a STEM subject in Year 12. The use of SEM allowed the researcher to investigate the mediating relationships between student level variables, addressing Data Question 2. Further, a more comprehensive exploration of the factors that influence the decisions of students entering Year 12 was needed. As outlined previously, research into gender roles and subject choice has shown that females show a propensity for enrolment in the health, social and biological sciences, with males choosing mathematics, chemical and physical sciences (Bennett & Hogarth, 2009; Bøe et al., 2011; Cerinsek, Hribar, Glodez, & Dolinsek, 2013; Fullarton & Ainley, 2000; National Academies of Sciences Engineering and Medicine, 2016a; Sikora, 2014a; Sikora & Pokropek, 2012b). It was hypothesised that the binary nature of the STEM subject choice variable lacked information at the level necessary to fully understand the difference in subject choice between males and females. For this reason, separate subject choice models were developed for physics and biology using PISA/LSAY 2006 data.

3.4.3.6. Data question 3: Year 12 subject choice – school factors

In order to investigate the influence of school related variables on students' STEM subject choice in Year 12, multilevel models were developed. The data explored in this research were of a hierarchical nature with students nested within schools. Multilevel modelling can be used effectively to analyse clustered data (Byrne, 2012) such as PISA and LSAY. In this research, data are "represented by a two-level structure, with the lower level representing individuals (e.g., students …) and the upper level representing groups (e.g., schools …)" (Byrne, 2012, p. 346). This type of analysis allowed the researcher to address the student and school level characteristics of the cohort by assessing the within- (student) and between- (school) level variance between variables simultaneously (Byrne, 2012). The student level multiple regression model developed in HLM developed to address Data Question 1 was extended to a second level to include information about students nested within schools. Again, an iterative process of testing alternative models of increasing complexity was undertaken. The first step was testing an intercepts model with a regression equation being added to the intercept of the outcome variable. This was followed by testing moderating effects of Level 2 variables on the parameters of the Level 1 demographic variables. A multilevel SEM was then developed using Mplus (Muthén & Muthén, 1998-2012). This method was chosen to improve the quality of findings from the moderated multiple regression model developed in HLM, due to the advantage it has for both practical and substantive reasons (Aguinis, Gottfredson, & Culpepper, 2013). The cross level interaction effects of school level variables on the slopes of relationships modelled on the student level were investigated. Cross-level interaction effects are concerned with whether a variable on the lower level (students) is dependent on variables from the higher level (schools) (Aguinis et al., 2013). More specifically, models that test for cross-level interaction effects highlight whether school level variables explain some of the variance of slopes across schools (Aguinis et al., 2013). Moderation effects of school level variables (ratio of native students, ratio of females, average school SES and school location) were investigated by examining the cross-level interaction effects on the slopes of paths from demographic variables (gender, SES and immigrant status) to the outcome (STEM subject choice). All moderation effects were modelled simultaneously in one combined model "so that each estimated effect is adjusted for all the theoretically relevant components" (Aguinis et al., 2013, p. 1515). Due to the increasingly complex nature of the model, decisions relating to model design and analysis were made to ensure convergence. This included altering the computation of the achievement variable from a latent variable including all five plausible values for both science and mathematics to a single indicator variable computed using the mean of the first plausible values for both science and mathematics. Altering the computation of the achievement variable allowed the researcher to overcome issues related to model identification. Further, standard integration was used as models estimated using Monte Carlo integration would not converge. A final multilevel model of STEM subject choice in Year 12 was produced.

3.5. Qualitative methods

In order to address Research Question 2 (How do background variables influence beliefs about STEM, intention towards STEM and enrolment in STEM subjects in Year 12?) a qualitative method of inquiry was deemed appropriate. Section 3.5.1 outlines the data collection procedures that were utilised in order to gain a variety of responses from the target population of interest, namely South Australian students entering Year 12. Section 3.5.2 describes the data analysis methods employed to generate themes within and across participants whilst addressing Research Question 2.

3.5.1. Data collection

Research Question 2 was addressed using qualitative methods. It sought rich descriptions and explanations using student voice and was informed by the findings from the initial quantitative phase. This phase utilised purposive sampling to recruit participants, the typical approach in qualitative research (Braun & Clarke, 2013). Purposive sampling allowed for the researcher to intentionally select participants from a variety of individual and school contexts across South Australia to better understand the problem of interest (Creswell, 2005). This stratified approach ensured that a “range and diversity of different groups in (the) population (were) included in (the) sample” (Braun & Clarke, 2013, p. 57). The variation in the purposive sampling technique was based on the factors of interest (school type, gender, STEM enrolment) as identified by the review of the literature and from the findings of the quantitative phase of the study. The anticipated sampling technique would have involved the recruitment of four Year 11 students (after Year 12 subject selection) from each school involved; a male and female who intended to enrol in a STEM subject, and a male and female with no intention to enrol in a STEM subject. In order to do this, all Year 11 students from participating schools were asked to complete a short questionnaire (screening tool) developed by the researcher which indicated various demographic and STEM subject intention information (see Appendix 1). All profiles were collated based on the four categories (Male STEM, Female STEM, Male Non-STEM and Female Non-STEM). Subjects classified as ‘STEM’ in South Australia were:

- Agricultural and Horticultural Science;
- Biology;
- Chemistry;
- Geology;
- Nutrition;
- Physics;
- Psychology;
- Scientific Studies;
- Information Technology;
- Mathematical Methods; and
- Specialist Mathematics.

A student was randomly selected from each category and asked to participate. If that student declined, another random draw was made until assent was received. Similarly, schools of differing types were first categorised and then randomly selected. If the principal or a nominee from that school declined to participate, then another random selection was undertaken until permission was received. Information relating to schools in South Australia was obtained from the Australian Curriculum, Assessment and Reporting Authority (ACARA). This provided the researcher with access to school information such as sector, location, size, SES (Index of Community Socio-educational Advantage (ICSEA), median=1000, SD=100), ratio of language other than English (LOTE) and ratio of gender. An initial list of school types that were approached is as follows:

- Metropolitan;
    - Public;
        - High SES (ICSEA > 1050);
        - Low SES (ICSEA < 950);
    - Private;
        - All boys;
        - All Girls;
        - Co-Educational;
- Rural/Regional;
    - Public;
        - Large (Enrolment > 600); and
        - Small (Enrolment < 200).

If the sampling strategy was enacted as intended it would have resulted in 28 participants, with an equal gender and STEM/Non-STEM proportion of students. Due to the difficult nature of attaining permission to conduct research in schools and student non-attendance, this was not often possible. Neither an all-boys nor co-educational private school was prepared to be involved in the study. Also, as a result of the findings from the quantitative study which highlighted differences between students from native and non-native backgrounds, schools who had higher proportions of LOTE students were approached. No schools of this type agreed to participate. Table 3-6 provides a breakdown of the school types that were involved and the students who participated from each school.

Table 3-6

Profile of students and schools involved in the study

School			Student Profile			
Sector	Location	Type	Male STEM	Female STEM	Male Non-STEM	Female Non-STEM
Public	Metropolitan	High SES	3	3		
		Low SES	1	2	1	
	Rural/ Regional	Large	1	2	1	
		Small	1	1	1	1
Private	Metropolitan	All Girls		1		1
Total			6	9	3	2

This type of sampling resulted in the selection of 20 students, which is in the typical range for a qualitative study aiming to identify patterns across data (Braun & Clarke, 2013).

In order to address Research Question 2, which attempts to understand the underlying decision-making process of students entering Year 12, semi-structured interview data was deemed appropriate in this context (Braun & Clarke, 2013). In this form of qualitative interviewing, the researcher had a pre-determined set of questions based on the factors of interest and underlying conceptual framework (TPB) and this was used as the basis for the interview protocol (see Appendix 2) and guided the discussion with the participant. The researcher, however, did not need to adhere to the protocol verbatim (Braun & Clarke, 2013). It was intended to gain a deeper understanding of the participant's "experiences and interpretations, in their own terms" (Punch & Oancea, 2014, p. 185). In this type of interview, the researcher was flexible and allowed the participant to go off on a tangent if it was perceived as interesting and potentially useful (Bryman, 2008).

The interviews were audio-recorded and transcribed verbatim. Verbatim transcription for thematic analysis required "a rigorous and thorough 'orthographic' transcript — a 'verbatim' account of all verbal (and sometimes nonverbal e.g., coughs) utterances" (Braun & Clarke, 2006, p. 88). A transcription notation system (Table 3-7) was used to ensure that a consistent approach was used during transcription (Braun & Clarke, 2013). Pauses, non-verbal communication, inaudible material and quotations were highlighted in the transcripts. Original transcripts are not included in the thesis.

Notes in the form of an interview protocol were utilised in the event of tape recorder malfunctions (Creswell, 2005).

Table 3-7

Transcription notation system

Notation Example	Meaning
I:	Interviewer is speaking
P:	Interviewee is speaking
Um, ah, dunno etc.	Non semantic and slang terms retained
[laugh] [cough]	Non-verbal utterance
[inaudible 3:12]	Words cannot be distinguished at a particular time of recording
(Biology teacher)	Protecting anonymity
…	Momentary pause
—	Sentence cut off by other person, trails off or changes thought
" "	Quoting what was said

3.5.2. Data analysis

Thematic analysis was used in this phase of the research as it is a suitable analytic method for addressing a research question that attempts to ascertain the underlying factors that influence an individual's decision (Braun & Clarke, 2013). Thematic analysis is a "method for identifying, analysing, and interpreting patterns of meaning ('themes') within qualitative data" (Clarke & Braun, 2017, p. 297). The general steps of thematic analysis described by Braun and Clarke (2006, 2013) were followed:

1. Familiarise yourself with the data;
2. Generate initial codes;
3. Search for themes;
4. Review themes;
5. Define and name themes; and
6. Produce the report.

The first step in analysing the qualitative data was to complete a preliminary exploratory analysis by reading the transcripts and getting a general sense of the data and making notes for later reflection (Creswell, 2005). Transcripts were then divided into keywords and text segments and labelled with codes using a process called complete coding (Braun & Clarke, 2013), which aims to "identify *anything* and *everything* of interest or relevance to answering your research question, within your entire dataset" (Braun & Clarke, 2013, p. 206). In the first instance, theoretical (deductive or 'top down') thematic coding (Braun & Clarke, 2013) was conducted. This meant that codes were grouped into themes predetermined by the underlying conceptual framework (TPB) (Creswell, 2005) and findings from the quantitative phase of the study. This provided evidence that:

1. Supported or challenged the findings from the quantitative phase of the study; and
2. Addressed findings highlighted in previous research, not covered in the quantitative phase of the study.

As concepts that were not explored in previous research or described in the underlying conceptual framework were of interest, coding was also approached in an inductive (bottom up) way. This provided evidence of new ideas that were worth exploring further. In the qualitative results chapter, participant excerpts provide evidence of the existence of themes. Excerpts are cleaned to edit out unnecessary detail or irrelevant material using "[..]". Punctuation is added where necessary to ensure readability. Notation " … " is used to signal separation between quotes from different parts of the interview, whilst addressing the same theme. Themes that were identified in the inductive coding phase are mapped to the underlying conceptual framework, the TPB. Combining both deductive and inductive analysis in a single analysis, as was done in this study, is common in qualitative research (Braun & Clarke, 2013). Themes were reviewed, defined and named so that the analysis provided a story or overall picture of the data in relation to the topic (Braun & Clarke, 2006). Identified themes attempted to "capture(s) something important about the data in relation to the research question, and represent(s) some level of *patterned* response or meaning within the dataset" (Braun & Clarke, 2006, p. 82). A theoretical lens (TPB) was imposed in order to make sense of participants'' responses in terms of the theory. Computer software NVivo 11 (QSR International Pty Ltd., 2015) was used due to its capabilities of managing data, managing ideas, querying data, producing graphical models and reporting from the data (Bazeley, 2007). The management capabilities of NVivo allowed each participant to be linked with their transcript, demographic information and subject choice information. Coding was then linked to each participant and the specific information of each participant. The ability to graphically model concepts and ideas that were being explored across cases allowed the researcher to build a narrative and identify overarching themes. The use of NVivo provided a platform to systematically approach thematic analysis in the same manner each time, ensuring a rigorous approach (Bazeley, 2007). Further analysis was undertaken through integration at the interpretation and reporting level via a narrative (Fetters, Curry, & Creswell, 2013). The contiguous approach of reporting the phases independently (Fetters et al., 2013) is used, i.e. Quantitative Results in Chapter 4 and Qualitative Results in Chapter 5. Following this, a discussion of themes that have resulted from an integration of results and findings from Chapters 4 and 5 is provided (see Chapter 6).

3.6. Ethical considerations

Ethics in research is concerned with the principles and rules that guide a researcher in the process of "planning, conducting, communicating and following up research" (Punch & Oancea, 2014, p. 58). Phase One data provided by PISA and LSAY was de-identified. Privacy, confidentiality and anonymity was upheld by giving pseudonyms to all participants in Phase Two. A letter of introduction was provided to prospective schools principals and parent(s)/caregiver(s) in the qualitative phase of the research. To guarantee that participants were informed and free from harm or risk, information sheets outlining the scope, purpose of the study and perceived benefit to participants was given to the principal of prospective schools and potential participants. The information sheet included information pertaining to the participants' rights including the right to refuse participation at any time. Principal consent to approach students within their schools was first gained either via email or in person. Student/parental consent forms were also provided. All data storage and retention was in accordance with the appropriate guidelines (Flinders University Deputy Vice-Chancellor (Research), 2014; National Health and Medical Research Council, 2007). Specific ethics approval was obtained from the Flinders University Social and Behavioural Research Ethics Committee, South Australian Department of Education and Childhood Development, and Catholic Education South Australia. No specific ethics application was needed for schools under the directorate of the Association of Independent Schools of South Australia, where permission was granted from the principal directly. All ethics related documents outlined in this section can be viewed in Appendix 3.

3.7. Limitations

There were several limitations when using secondary data in this research. The researcher had a lack of familiarity with the data set being used (Bryman, 2008). A significant period of familiarisation was undertaken to ensure coding and structural aspects were understood. PISA and LSAY data are extremely complex, with a significantly large number of variables and respondents. It was ensured that the researcher had a detailed understanding of the types of analyses that were to be undertaken prior to extracting the necessary information from these datasets. Another limitation of secondary data is the lack of control over data quality (Bryman, 2008). However, OECD used extremely strict guidelines in the design of questionnaires, sampling techniques and collection of data. The data and key variables included in secondary data may not match the purpose of a proposed study (Bryman, 2008). To minimise this type of limitation, PISA and LSAY were chosen as the intended secondary data sets as they had a large range of variables that suited the current investigation. Subject choice information in the PISA/LSAY datasets did not specify the year level of subjects and was generically worded. For this reason, datasets were split to include only students who were identified as being in Year 12 or 13. This means that those students in Year 10 or 11 who may have studied a Year 12 STEM subject were excluded. However, it was anticipated that a student who studied a Year 12 STEM subject before their final year of schooling would likely have enrolled in another STEM subject in Year 12, therefore being included due to the binary nature of the outcome variable. A substantial proportion of the population being investigated in this research was not included due to attrition. This attrition could be due to leaving school early, or not agreeing to participate in the initial PISA survey or subsequent LSAY surveys. The demographic profiles of students in the analysis sample and the attrition sample can be seen in Table 3-8.

Table 3-8

Demographic profile of participants from the analysis and attrition samples

	% (Attrition Sample)	% (Thesis Sample)
Female	43.5	54.4
Native	82.8	78.2

It is clear that there are differences between the two cohorts. Table 3-9 shows a breakdown of the differences in SES, attitudes towards science and achievement in science and mathematics between the attrition and thesis samples.

Table 3-9

Descriptive statistics for participants from the analysis and attrition samples

	Mean (Attrition Sample)	Mean (Thesis Sample)
SES	0.017	0.345
Personal Value of Science	-0.145	0.163
Enjoyment of Science	-0.287	0.098
Self-Concept in Science	-0.218	0.025
PV in Science	486.841	555.735
PV in Mathematics	484.978	544.488

Students included in the thesis sample had higher values on average on SES, attitudes towards science, and achievement in science than the attrition sample in all areas examined. This likely affected the relationships between student and school level variables included in the models for STEM, Physics and Biology subject choice in Year 12.

A limitation of the qualitative phase of the study was the issue of subjectivity. Qualitative findings can be biased by the researchers' pre-existing assumptions and knowledge of the topic, influencing the analysis of data and subsequent findings (Bryman, 2008). With the interpretivist approach that was utilised in this phase, it was approached as a constructed understanding around a phenomenon through semi-structured interviews. Issues of generalisability are often raised in discussion around qualitative research. This study acknowledged that the small sample size from purposively selected schools was not representative of the whole population. It was recognised that with qualitative interviewing, the participants may not have been able to equally articulate meaning or their perception of understanding (Creswell, 2014). However, an advantage of the qualitative phase of the study which enhances the overall quality of the research is that the qualitative data provides an in-depth consideration of reasons for student choices through rich descriptions generated from what students said in interviews. The nuances of thinking is a limitation of the quantitative data set that the qualitative approach could somewhat address, i.e. they are complementary.

There are several critiques of using computer software for aiding in the analysis of qualitative data. Bazeley (2007) has cited early opposition to software use in qualitative research, suggesting that "users of software lost closeness to data through poor screen display, segmentation of text and loss of context, and thereby risked alienation from their data" (p. 8). The first step in the thematic analysis approach that was adopted in this research accounted for this, where a period of familiarisation was undertaken with the researcher re-listening to audio, reading and re-reading transcripts and noting down initial ideas. Software has also been perceived as purely a 'code and retrieve' mechanism, where text segments are removed from the greater text, losing perspective (Bazeley, 2007). In order to account for this, text segments that were used to provide anecdotal evidence for the existence of a theme were checked to ensure that the context was appropriate for the theme being described.

3.8. Delimitations

The first delimitation was in narrowing and defining the scope of the study (Jha, 2014), focussing on senior secondary subject choice excluding primary, lower secondary, tertiary education and career paths. It also excluded Year 11 subjects because mathematics was compulsory for one semester at Year 11 in South Australia. For practicality and ease of definition, this study focussed solely on STEM subjects in Year 12. The scope of the qualitative phase of the study focussed on students within South Australia rather than nationwide. As the qualitative phase was not intended to be generalizable, the numbers of schools and participants were carefully selected with respect to time, money and resources (Jha, 2014). The use of secondary data reduced the large task of sampling, questionnaire design, participant recruitment and data entry. The use of a pre-existing conceptual framework allowed for a clearly defined direction with potential variables of interest identified.

3.9. Summary

Details described in this chapter provide the context of the research problem, the research and data questions that were developed to answer it, and the methods employed that provided the results to explain it. A detailed description of the quantitative and qualitative data collection and analysis procedures that were used, is provided. This includes correlational analysis, structural equation modelling and multilevel modelling of secondary data from PISA and LSAY. Interviews with students entering Year 12 in South Australia provided in depth information that helped to determine the process that leads to students' STEM enrolment decisions. Integration of quantitative and qualitative results provided a clearer overview of the research problem. A short discussion of the ethical considerations, limitations and delimitations related to the research is presented.

4. QUANTITATIVE RESULTS

4.1. Introduction

This chapter outlines the results of the quantitative analyses using PISA 2006 and LSAY (Waves 2-4) data that address Research Question 1 “What factors (student and school) influence students’ STEM enrolment decisions in Year 12?”. Section 4.2 presents descriptive statistics which provide an outline of the frequency and percentage of both categorical and continuous student and school level variables included in the study. Table 3-1, which was presented in Section 3.4.3 outlined the quantitative data analysis plan used in this study and provided information that summarises the type of analyses (single or multilevel, regression or SEM, outcome variable, and software package) that would done to address each Data Question (1, 2 and 3). Section 4.3 addresses Data Question 1 “What student factors directly influence Year 12 STEM student enrolment decisions?” and Data Question 2 “What student factors mediate the relationship between Year 12 students’ demographic backgrounds and STEM subject choice?”. In this section, single (student) level multiple regression models developed using HLM (Raudenbush et al., 2013) and single (student) level SEMs using Mplus (Muthén & Muthén, 1998-2012) focussing solely on student level factors of influence are presented. A breakdown into the direct and indirect (mediating) effects of demographic background (gender, SES and immigrant status), attitudes towards science (personal value of science, enjoyment of science and self-concept in science), and achievement in science and mathematics on STEM subject choice is outlined (see Section 4.3.1.). Subject choice models for Physics and Biology subject choice in Year 12 are also presented to address the nuances of STEM subject choice decisions (see Sections 4.3.2. and 4.3.3.). Section 4.4 addresses Data Question 3 “What school level factors moderate the relationships between Year 12 students’ demographic background and STEM subject choice?”. In this section, a multilevel multiple regression model using HLM and a multilevel SEM using Mplus that extend the single (student) level models to explore the influence of school variables on STEM as a whole subject choice in Year 12 are also presented. This model addresses the moderating (cross-level interaction) effects of school level variables (school location, ratio of females, ratio of native students and average SES) on the relationship between demographic background (gender and immigrant status) and STEM subject choice in Year 12. Due to the increased model complexity, developing models with additional variables beyond those included in the final presented multilevel SEM was not computationally viable.

4.2. Descriptive statistics

Descriptive statistics for students (N=7,442) and schools (N=353) involved in the research sample are included in this section. The frequency and percentage breakdown for categorical student level variables used in this study are presented in Table 4-1, using unweighted data from the first imputed dataset.

Table 4-1

Percentage of subject choice by students from varying demographic backgrounds

	Gender		Immigrant status	
Construct	Male	Female	Native	Non-native
STEM Subject Choice in Year 12	65.8	56.3	58.2	69.6
Physics subject choice in Year 12	21.5	7.5	11.8	21.5
Biology subject choice in Year 12	17.9	29.7	23.6	26.9

As can be seen from Table 4-1, males are more likely to enrol in STEM and Physics than female students, where the reverse effect exists for biology. Also, native students are less likely to enrol in STEM, Physics and Biology than their non-native counterparts. In order to assess the distribution of continuous student level variables, descriptive statistics (mean, standard deviation, skewness and kurtosis) are presented in Table 4-2, using unweighted data from the first imputed dataset.

Table 4-2

Descriptive statistics for continuous student level variables

Construct	Mean	SD	Skewness	Kurtosis
SES	0.35	0.74	-0.29	0.00
Personal Value of Science	0.16	1.06	0.06	0.18
Enjoyment of Science	0.10	1.00	-0.11	-0.11
Self-Concept in Science	0.03	0.98	-0.13	0.29
Plausible Value in Science 1	555.74	91.75	-0.20	0.01
Plausible Value in Science 2	556.42	91.29	-0.23	-0.07
Plausible Value in Science 3	555.77	91.86	-0.22	-0.01
Plausible Value in Science 4	555.73	91.38	-0.21	-0.07
Plausible Value in Science 5	556.51	92.11	-0.22	-0.02
Plausible Value in Mathematics 1	544.49	80.98	-0.04	-0.06
Plausible Value in Mathematics 2	544.62	80.81	-0.10	-0.08
Plausible Value in Mathematics 3	544.79	80.54	-0.08	-0.06
Plausible Value in Mathematics 4	544.57	80.88	-0.08	-0.08
Plausible Value in Mathematics 5	544.99	80.74	-0.07	-0.06

Table 4-2 provides an account of the distribution of continuous student level variables used in the study. A similar process was undertaken for schools involved in the process, with descriptive statistics provided for continuous school level variables presented in Table 4-3.

Table 4-3

Descriptive statistics for continuous school level variables

Construct	Mean	SD	Skewness	Kurtosis
Ratio of Female Students	0.54	0.24	-0.24	0.64
Average School SES	0.26	0.39	-0.01	0.24
Ratio of Native Students	0.80	0.20	-1.32	1.34

Only one categorical school level variable was used in the research. 65.5% of students attended metropolitan schools whilst the remaining students in the sample (34.5%) attended rural, regional or remote schools.

4.3. The influence of student level factors on STEM subject choice in Year 12

Results provided in this section address Data Question 1 "What student factors directly influence Year 12 STEM student enrolment decisions?" and Data Question 2 "What student factors mediate the relationship between Year 12 students' demographic backgrounds and STEM subject choice?". First, a student level model of STEM subject choice was developed (see Section 4.3.1.). The adapted theory of planned behaviour (TPB) model that was presented in Chapter 2 was used to guide analyses and interpretation of results. Items available in both the PISA and LSAY datasets were mapped to the adapted TPB model and tested. Initially, exploratory models of STEM subject choice were developed and tested in HLM using multiple regression with full maximum likelihood estimation using numerical integration via adaptive Gaussian quadrature (AGQ). Findings from this exploratory phase were then used in the development of a SEM in Mplus using a robust weighted least square estimation technique (WLSMV) for STEM subject choice. Direct effects and indirect effects (mediating relationships) were considered in order to adequately address both Data Question 1 and Data Question 2. The dichotomisation of STEM may be too coarse and that stark differences between groups of varying demographic backgrounds may exist when individual subjects are considered. Therefore, SEMs for Physics subject choice in Year 12 and Biology subject choice in Year 12 were tested and the results are presented in Sections 4.3.2. and 4.3.3. respectively.

4.3.1. STEM as a whole subject choice in Year 12

In order to first explore the relationship between students' demographic background, attitude towards science, achievement in science and mathematics, and STEM subject choice in Year 12, a series of multiple regression models were developed in HLM (see Section 4.3.1.1.). Following this, SEMs were developed in Mplus to confirm the findings of the multiple regression models and explore the mediating relationships between variables (see Section 4.3.1.2.).

4.3.1.1. Multiple regression model

Using the first imputed dataset (full sample), a series of models of increasing complexity were tested in HLM in order to explore potentially influencing factors in the STEM subject choice decisions of students entering Year 12. First, a null (unconstrained) model (1) was tested to assess the variance in the intercept term of the student level outcome variable. Following this, demographic variables (gender, SES and immigrant status) were added to the model (2). Model 3 added attitudinal variables (enjoyment of science, personal value of science and self-concept in science) whilst the final student level model (4) added achievement in science and mathematics. The results of the four models are provided in Table 4-4. Models increase in complexity in an attempt to decrease residual variance and improve explanatory power. Unstandardised regression estimates are provided with levels of significance along with standard error values for each predictor in the models. Deviance statistics (-2 log likelihood) for individual models independent of other models are provided. Likelihood ratio tests were used to compare models to determine which of them more adequately fit the data. Model 2 (demographic) is a better fitting model than Model 1 (null model) ($\chi^2(3)=177.22$, $p<0.001$). Model 3 (demographic and attitudinal) is a better fitting model than Model 2 (demographic) ($\chi^2(3)=862.51$, $p<0.001$). Model 4 (demographic, attitudinal and achievement) is a better fitting model than model 3 (demographic and attitudinal) ($\chi^2(1)=361.91$, $p<0.001$).

Table 4-4

Student level multiple regression model of STEM subject choice in Year 12

	Model 1	Model 2	Model 3	Model 4
Fixed Effect				
Intercept, γ00	0.42* (0.041)	0.95* (0.073)	0.79* (0.079)	-3.48* (0.24)
Female, γ10		-0.38* (0.054)	-0.20 (0.059)	-0.15* (0.060)
SES, γ20		0.31* (0.037)	0.16* (0.039)	0.0053 (0.041)
Native, γ30		-0.52* (0.067)	-0.41* (0.072)	-0.51* (0.074)
EnjoySc, γ40			0.41* (0.043)	0.30* (0.044)
PerValSc, γ50			0.28* (0.036)	0.26* (0.037)
SlfConSc, γ60			0.26* (0.039)	0.11* (0.041)
AchSciMat (Mod), γ70				0.16* (0.0088)
Variance Estimate				
Intercept Variance, μ0	0.36*	0.29*	0.34*	0.33*
Deviance	23,438	23,260	22,398	22,036

Note. * indicates significance ($p<0.05$). Standard error estimates in brackets.

The final accepted model (4), which more adequately fits the data when compared with nested models, was examined to assess the results of the multiple regression model. Demographic characteristics are shown to be influential in the decisions of students deciding whether they are going to enrol in a STEM subject in Year 12. Gender is shown to be a significant predictor with females ($B=-0.15$, $p<0.05$) less likely to choose a STEM subject than males. It is important to note that when other variables of interest are added to the models, the effect of Gender declines, suggesting that this effect is mediated by other variables. Although SES is shown to be a significant predictor in earlier models (2 and 3), it was not shown to be significant ($B=0.0053$, $p>0.05$) in the final accepted model. This may mean that with the inclusion of other predictor variables, a suppression effect may have occurred. It may also mean that SES operates as an indirect (as opposed to a direct) predictor of STEM subject choice through interactions with other variables. These indirect effects are explored in the following section. Immigrant status is a significant predictor with native students ($B=-0.51$, $p<0.001$) less likely to enrol in STEM than non-native students. Variables related to students' attitudes towards science are shown to be influential in the STEM decision-making process. Enjoyment of science ($B=0.30$, $p<0.001$), personal value of science ($B=0.26$, $p<0.001$) and self-concept in science ($B=0.11$, $p<0.01$) are all significant positive predictors of STEM subject choice in Year 12. Students' achievement in science and mathematics ($B=0.16$, $p<0.001$) was also a significant predictor of STEM subject choice. Results from the student level multiple regression models provided in this section give an indication of potentially influential factors in the STEM subject choice decisions of students entering Year 12. They also help in the development of SEMs to further explore the complex direct and indirect effects of student level variables on STEM subject choice. These SEMs are explored in Section 4.3.1.2.

4.3.1.2. Structural equation model

Results from exploratory analyses, including descriptive statistics and student level multiple regression models, were used in the development of a SEM for STEM subject choice in Year 12. This resulted in a student level model with demographic variables (gender, SES and immigrant status) leading to STEM subject choice mediated by attitudes towards science (enjoyment of science, personal value of science, and self-concept in science) and achievement in science and mathematics. As outlined in Chapter 3, the final accepted version for each of the presented models was developed and tested following Kline's (2016) basic steps of SEM analysis. Alternative models were tested with differing choices of attitudinal variables available in PISA/LSAY datasets. The model for STEM subject choice was also adapted for Physics and Biology subject choice, and extended for the multilevel model of STEM subject choice. Paths that were estimated and retained in the model were based on theoretical and statistical reasoning. The basis of inclusion was the level of significance and size of regression estimates (e.g. self-efficacy in science and motivation for science were not retained in the model). As the demographic backgrounds of students were of most interest, special consideration was given to the relationships between gender, SES, immigrant status and STEM subject choice in Year 12. Therefore, direct paths from demographic variables to subject choice were retained in the model whether they were significant predictors or not as it was anticipated that they may be important in subsequent multilevel models.

The final accepted model of STEM subject choice in Year 12 using the full sample with aggregated estimates across 20 imputed datasets suggested an adequate fit to the data (Mean $\chi2(99)=367.286$, SD=6.081, CFI=0.982, TLI=0.976, RMSEA=0.019). A standardised path diagram can be seen in Figure 4-1. Attitudinal variables were allowed to covary as they were expected to be, and observed to be, correlated. Paths estimated in the model are significant ($p<0.05$) except where indicated in the diagram using a dashed line. This non-significant path has been included in the model due to its theoretical interest. Standardised direct and indirect effects were estimated and are shown in Table 4-5. Unstandardised effects are available in Appendix 4.

The demographic background of students is shown to be influential in whether they enrolled in a STEM subject in Year 12. In particular, gender is a significant predictor with females ($\beta=-0.098$, $p<0.01$) less likely to choose STEM than males. This finding is similar to research presented by Jaremus, Gore, Fray and Prieto-Rodriguez (2018), where data from New South Wales (NSW) showed females have consistently been less likely than males to enrol in physics, chemistry, earth science, digital technologies, engineering and extended mathematics over the past 25 years. In the present research, immigrant status is also a significant predictor, with native students ($\beta=-0.204$,

$p<0.001$) less likely to enrol in a STEM subject in Year 12 than those students who came from first- and second-generation migrant families. In a study conducted in the UK, Tripney et al. (2010) found that students from Asian backgrounds were more likely to enrol in science and mathematics than other students, but the findings should be treated with caution as the definition of Asian in the study they cited incorporated different cultural and ethnic backgrounds. In the current study SES ($\beta=0.011$, $p>0.05$) is not a significant direct predictor. Students' attitude towards science does influence their decision to enrol in a STEM subject in Year 12. If a student has a higher personal value of science ($\beta=0.154$, $p<0.001$), they are more likely to enrol in STEM. Students who enjoy science ($\beta=0.104$, $p<0.001$) are also more likely to enrol in a STEM subject in Year 12. A student with a high self-concept in science is more likely to enrol in STEM ($\beta=0.051$, $p<0.05$). Higher achievement in science and mathematics ($\beta=0.325$, $p<0.001$) is a positive predictor of a student's likelihood to enrol in a STEM subject.

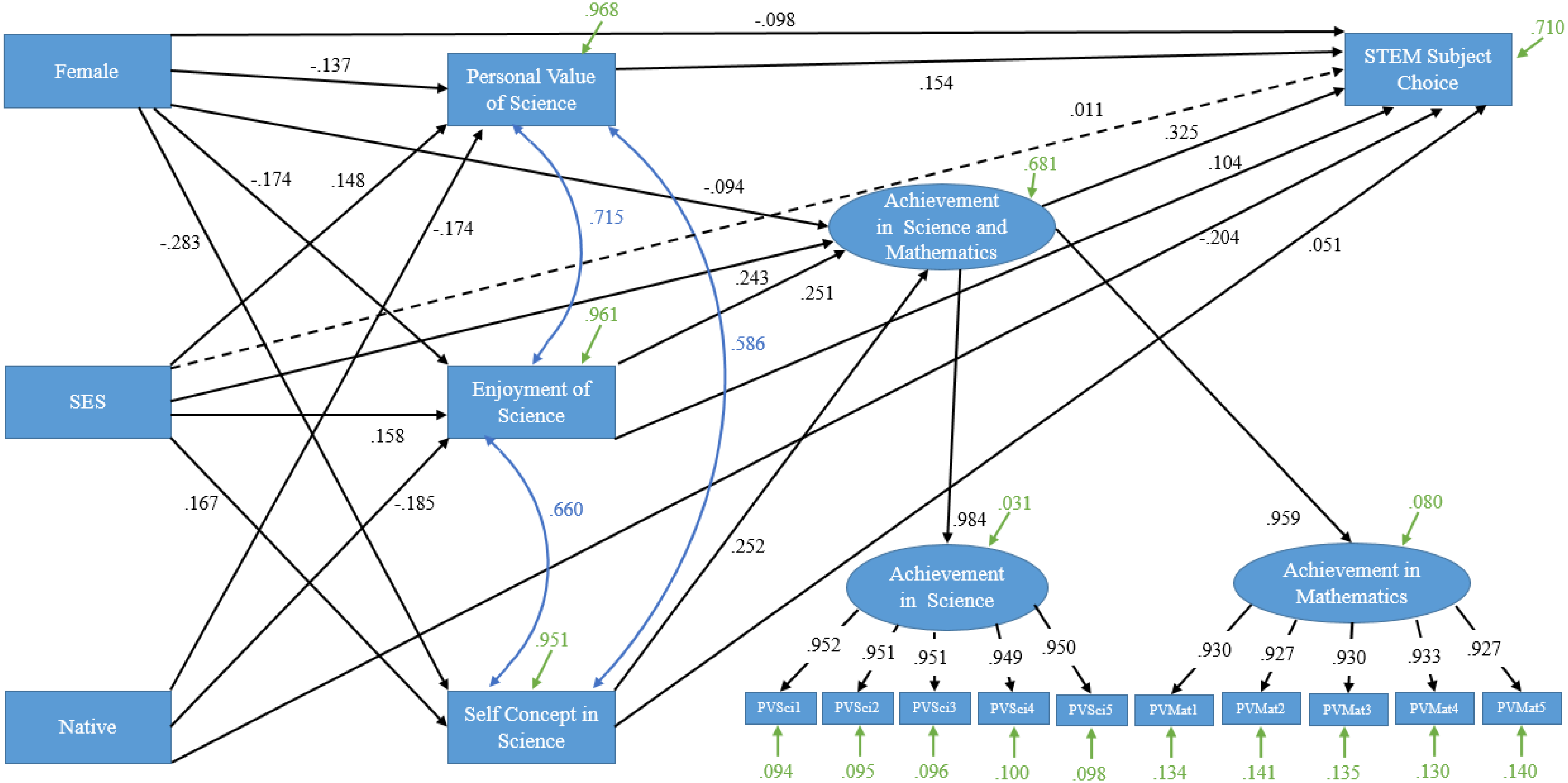

Figure 4-1. STEM subject choice model diagram (standardised).

Note. Full cohort with aggregated results of 20 imputations. Dashed line represents non-significant path (0.05 level). Values in green represent residual variances. Values in blue represent covariances.

Table 4-5

Direct and indirect effects on STEM subject choice (Standardised) (Pooled)

	Direct Effects				Indirect Effects				Total Effects			
	β	SE β	Z	p	β	SE β	Z	p	β	SE β	Z	p
Female - STEMSub	-0.098	0.038	-2.608	0.009								
Female - AchSciMat - STEMSub					-0.031	0.011	-2.785	0.005				
Female - EnjoySc - AchSciMat - STEMSub					-0.014	0.003	-5.123	<0.001				
Female - SlfConSc - AchSciMat - STEMSub					-0.023	0.003	-7.306	<0.001				
Female - PerValSc - STEMSub					-0.021	0.005	-4.064	<0.001				
Female - EnjoySc - STEMSub					-0.018	0.006	-3.101	0.002				
Female - SlfConSc - STEMSub					-0.014	0.007	-2.164	0.030				
Sum of Indirect Effects (Female to STEMSub)					-0.122	0.017	-7.081	<0.001				
Sum of Direct and Indirect Effects (Female to STEMSub)									-0.220	0.039	-5.621	<0.001
SES - STEMSub	0.011	0.019	0.585	0.558								
SES - AchSciMat - STEMSub					0.079	0.007	10.662	<0.001				
SES - EnjoySc - AchSciMat - STEMSub					0.013	0.002	7.074	<0.001				
SES - SlfConSc - AchSciMat - STEMSub					0.014	0.002	7.211	<0.001				
SES - PerValSc - STEMSub					0.023	0.004	5.251	<0.001				
SES - EnjoySc - STEMSub					0.016	0.005	3.463	0.001				
SES - SlfConSc - STEMSub					0.009	0.004	2.149	0.032				
Sum of Indirect Effects (SES to STEMSub)					0.153	0.010	15.212	<0.001				
Sum of Direct and Indirect Effects (SES to STEMSub)									0.164	0.020	8.385	<0.001
Native - STEMSub	-0.204	0.046	-4.452	<0.001								
Native - EnjoySc - AchSciMat - STEMSub					-0.015	0.006	-2.659	0.008				
Native - PerValSc - STEMSub					-0.027	0.006	-4.261	<0.001				
Native - EnjoySc - STEMSub					-0.019	0.009	-2.193	0.028				
Sum of Indirect Effects (Native to STEMSub)					-0.061	0.016	-3.878	<0.001				
Sum of Direct and Indirect Effects (Native to STEMSub)									-0.265	0.050	-5.259	<0.001
PerValSc - STEMSub	0.154	0.025	6.051	<0.001					0.154	0.025	6.051	<0.001
EnjoySc - STEMSub	0.104	0.028	3.673	<0.001								
EnjoySc - AchSciMat - STEMSub					0.082	0.008	10.336	<0.001				
Sum of Direct and Indirect Effects (EnjoySc to STEMSub)									0.186	0.029	6.471	<0.001
SlfConSc - STEMSub	0.051	0.023	2.233	0.026								
SlfConSc - AchSciMat - STEMSub					0.082	0.008	9.727	<0.001				
Sum of Direct and Indirect Effects (SlfConSc to STEMSub)									0.133	0.023	5.835	<0.001
AchSciMat - STEMSub	0.325	0.023	14.289	<0.001					0.325	0.023	14.289	<0.001

The results from the SEM for STEM subject choice in Year 12 also provide information that helps to explain the effect of a series of mediating relationships between students' demographic backgrounds, attitudes towards science, achievement in science and mathematics, and STEM subject choice in Year 12. The relationship between a student's demographic background and its influence on whether they enrolled in a STEM subject in Year 12 is complex, as illustrated by the number of significant indirect effects and mediating relationships shown in Table 4-5. The indirect effect of gender (Female: $\beta=-0.122, p<0.001$), mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and mathematics, is significant. The total effect of gender (Female: $\beta=-0.220, p<0.001$) on STEM subject choice is significant. The indirect effect of immigrant status (Native: $\beta=-0.061, p<0.001$), mediated by personal value and enjoyment of science and achievement in science and mathematics, is also significant. This results in a total significant effect of immigrant status (Native: $\beta=-0.265, p<0.001$) on STEM subject choice. SES ($\beta=0.153, p<0.001$) is shown to be a significant indirect predictor, mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and mathematics. The total effect of SES ($\beta=0.164, p<0.001$) is significant. This finding highlights the complex relationship between SES and STEM subject choice being predominantly a significant indirect predictor. Tripney et al. (2010) discussed this phenomenon with some studies showing a direct effect whilst others did not. The authors of the review suggested that prior achievement was not controlled for in two of the studies. This is not the case in the current research, explaining the indirect effect. The effect of attitudes towards science on STEM subject choice is mediated by achievement in science and mathematics. A student's enjoyment of science ($\beta=0.082, p<0.001$) indirectly influences whether they enrol in STEM, mediated by achievement in science and mathematics. This results in a total significant effect of enjoyment of science ($\beta=0.186, p<0.001$) on STEM subject choice in Year 12. The indirect effect of self-concept in science ($\beta=0.082, p<0.001$), mediated by achievement in science and mathematics, is significant. The total effect of self-concept in science ($\beta=0.133, p<0.001$) is significant.

The proportion of explained variance (R Square) for mediating and outcome variables is shown in Table 4-6. This table indicates how well each dependent variable can be explained by the preceding independent variables in the model. Of particular interest is STEM subject choice, with 29% of its variance explained by the variance of preceding variables in the model.

Table 4-6

Proportion of explained variance (R Square) (Pooled), STEM Model

	Estimate		
Construct	R^2	SE	p
Personal Value of Science	0.032	0.005	<0.001
Enjoyment in Science	0.039	0.007	<0.001
Self-Concept in Science	0.049	0.007	<0.001
Achievement in Science and Mathematics	0.319	0.013	<0.001
STEM Subject Choice (Outcome)	0.290	0.017	<0.001

The results of the student level model for STEM subject choice in Year 12 provided useful and insightful information relating to the factors of influence in a student's decision-making process. However, research by Sikora (2013, 2014a) and Ainley, Kos and Nicholas (2008) highlighted that the dichotomisation of STEM subject choice may be too coarse and further investigation was needed to reveal the differences in individual subjects that constitute STEM. It was particularly important to investigate the gender differences between Physics subject choice and Biology subject choice. This prior research (Ainley et al., 2008; Sikora, 2013, 2014a) found that males were more likely to enrol in physical science (physics) subjects, whereas females were more likely to enrol in life science (biology) subjects. For this reason, path models for Physics and Biology subject choices in Year 12 are presented in Sections 4.3.2. and 4.3.3.

4.3.2. Physics subject choice in Year 12

As mentioned in the previous section, the basic structure of the Physics subject choice model (SEM only) presented in this section is the same as the previously discussed STEM subject choice model with a different outcome variable. However, the model building process was conducted from the beginning resulting in differing paths being estimated and regression weights changing between models. As outlined above, the proposed model consists of demographic variables (Gender, SES and Immigrant Status) leading to Physics subject choice mediated by attitudes towards science (enjoyment of science, personal value of science and self-concept in science) and achievement in science and mathematics.

The final accepted model of Physics subject choice in Year 12 using the full sample with aggregated estimates across 20 imputed datasets suggested an adequate fit to the data (Mean $\chi2(102)=308.424$, SD=4.179, CFI=0.987, TLI=0.982, RMSEA=0.016). The standardised model is presented in Figure 4-2. Attitudinal variables have been allowed to covary due to the high correlations between them. Paths estimated in the model are significant ($p<0.05$) except where indicated in the diagram using a dashed line. This non-significant path has been retained in the model due to its theoretical interest. Standardised direct and indirect effects were estimated and are shown in Table 4-7. Unstandardised effects are available in Appendix 5.

A student's demographic background is shown to be influential in the decision of whether to enrol in Physics in Year 12. Gender is a significant predictor with females ($\beta=-0.475$, $p<0.001$) less likely to choose Physics than males. This finding is comparable with results from the Trends in International Mathematics and Science study (TIMSS) in 2015 with females less likely to enrol in advanced physics than males in most countries (Chavatzia, 2017). In the present study, immigrant status is a significant predictor, with native students ($\beta=-0.334$, $p<0.001$) less likely to enrol in Physics in Year 12 than non-native students. However, SES ($\beta=-0.031$, $p>0.05$) is not a significant direct predictor. Attitude towards science is also shown to be influential over a student's decision to enrol in a Physics subject in Year 12. Students with a higher personal value of science ($\beta=0.182$, $p<0.001$) are more likely to enrol in Physics. Those students with a higher self-concept in science ($\beta=0.189$, $p<0.001$) are also more likely to enrol in Physics than those with low self-concept. Students with higher levels of achievement in science and mathematics ($\beta=0.383$, $p<0.001$) are more likely to enrol in Physics than those with lower levels of achievement.

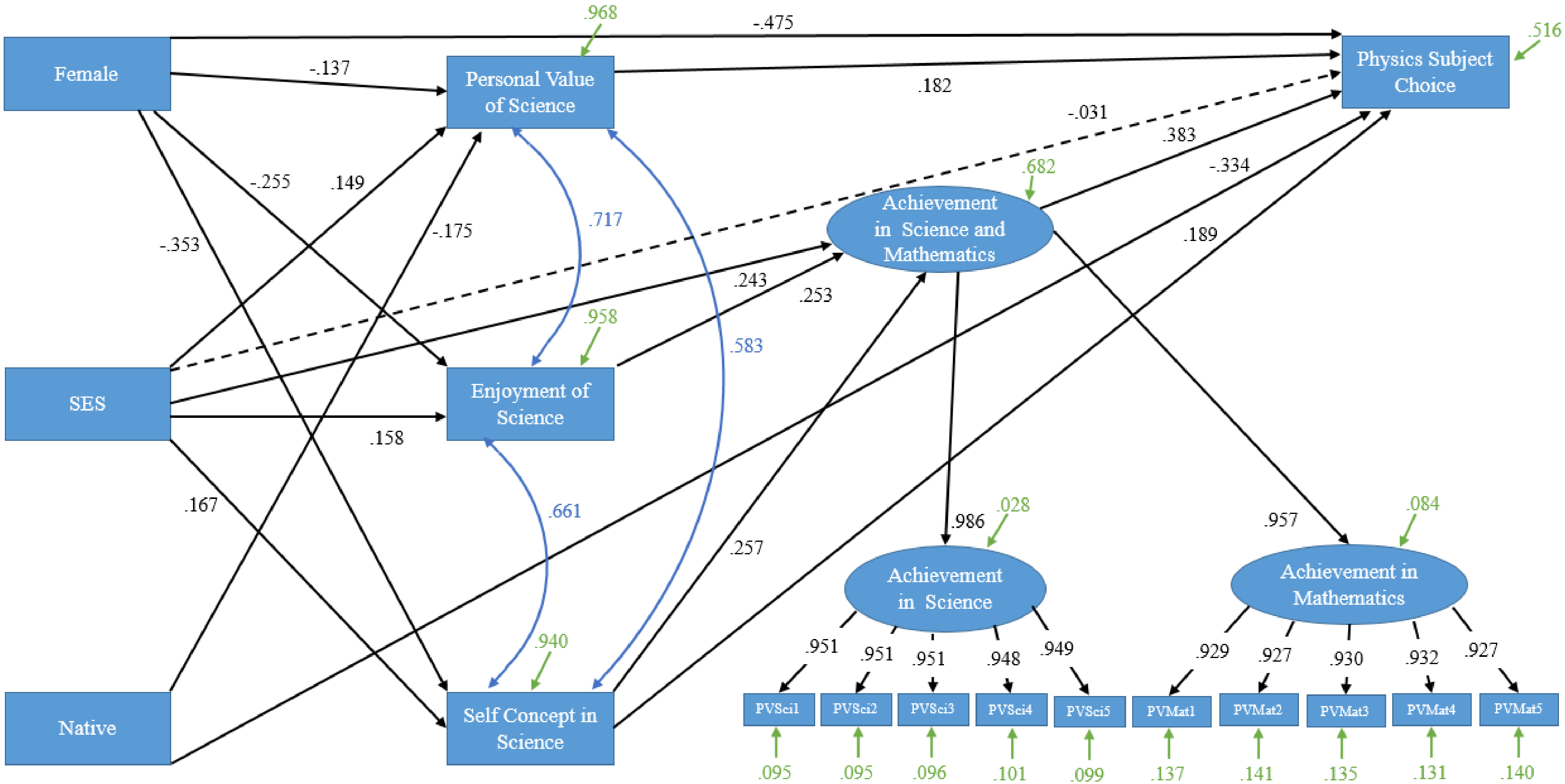

Figure 4-2. Physics subject choice model diagram (standardised).
Note. Full cohort with aggregated results of 20 imputations. Dashed line represents non-significant path (0.05 level). Values in green represent residual variances. Values in blue represent covariances.

Table 4-7

Direct and indirect effects on Physics subject choice (Standardised) (Pooled)

	Direct Effects				Indirect Effects				Total Effects			
	β	SE β	Z	p	β	SE β	Z	p	β	SE β	Z	p
Female - PhysicsSub	-0.475	0.040	-11.987	<0.001								
Female - EnjoySc - AchSciMat - PhysicsSub					-0.025	0.004	-5.658	<0.001				
Female - SlfConSc - AchSciMat - PhysicsSub					-0.035	0.005	-7.297	<0.001				
Female - PerValSc - PhysicsSub					-0.025	0.006	-4.320	<0.001				
Female - SlfConSc - PhysicsSub					-0.067	0.012	-5.714	<0.001				
Sum of Indirect Effects (Female to PhysicsSub)					-0.151	0.019	-8.149	<0.001				
Sum of Direct and Indirect Effects (Female to PhysicsSub)									-0.626	0.041	-15.212	<0.001
SES - PhysicsSub	-0.031	0.021	-1.463	0.143								
SES - AchSciMat - PhysicsSub					0.093	0.007	12.454	<0.001				
SES - EnjoySc - AchSciMat - PhysicsSub					0.015	0.002	7.140	<0.001				
SES - SlfConSc - AchSciMat - PhysicsSub					0.016	0.002	8.148	<0.001				
SES - PerValSc - PhysicsSub					0.027	0.004	6.261	<0.001				
SES - SlfConSc - PhysicsSub					0.032	0.005	5.848	<0.001				
Sum of Indirect Effects (SES to PhysicsSub)					0.183	0.012	15.865	<0.001				
Sum of Direct and Indirect Effects (SES to PhysicsSub)									0.152	0.023	6.618	<0.001
Native - PhysicsSub	-0.334	0.049	-6.829	<0.001								
Native - PerValSc - PhysicsSub					-0.032	0.007	-4.467	<0.001				
Sum of Direct and Indirect Effects (Native to PhysicsSub)									-0.366	0.051	-7.175	<0.001
PerValSc - PhysicsSub	0.182	0.024	7.631	<0.001					0.182	0.024	7.631	<0.001
EnjoySc - AchSciMat - PhysicsSub					0.097	0.009	10.488	<0.001	0.097	0.009	10.488	<0.001
SlfConSc - PhysicsSub	0.189	0.025	7.448	<0.001								
SlfConSc - AchSciMat - PhysicsSub					0.098	0.008	11.886	<0.001				
Sum of Direct and Indirect Effects (SlfConSc to PhysicsSub)									0.287	0.025	11.465	<0.001
AchSciMat - PhysicsSub	0.383	0.020	19.168	<0.001					0.383	0.020	19.168	<0.001

Similar to the previously presented model for STEM subject choice, a student's enrolment in Physics in Year 12 is influenced by a number of direct and indirect effects from demographic characteristics, attitudes towards science and achievement in science and mathematics, as can be seen in Table 4-7. The indirect effect of gender (Female: β=-0.151, p<0.001), mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and mathematics, is significant. The total effect of gender (Female: β=-0.626, p<0.001) on Physics subject choice is significant. The indirect effect of immigrant status (Native: β=-0.032, p<0.001), mediated by personal value of science is also significant. This results in a total significant effect of immigrant status (Native: β=-0.366, p<0.001) on Physics subject choice. SES (β=0.183, p<0.001) is shown to be a significant indirect predictor, mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and mathematics. The total effect of SES (β=0.152, p<0.001) is significant. The effect of attitudes towards science on Physics subject choice is mediated by achievement in science and mathematics. A student's enjoyment of science (β=0.097, p<0.001) indirectly influences whether they enrol in Physics, mediated by achievement in science and mathematics. The indirect effect of self-concept in science (β=0.098, p<0.001), mediated by achievement in science and mathematics, is significant. The total effect of self-concept in science (β=0.287, p<0.001) is significant.

The proportion of explained variance (R Square) for mediating and outcome variables is shown in Table 4-8. This table shows that 48.4% of the variance in Physics subject choice can be explained by the variance of the preceding variables in the model.

Table 4-8

Proportion of explained variance (R Square) (Pooled), Physics Model

	Estimate			
Construct	R^2	SE	R^2/ SE	p
Personal Value of Science	0.032	0.005	6.288	<0.001
Enjoyment in Science	0.042	0.007	5.918	<0.001
Self-Concept in Science	0.060	0.008	7.496	<0.001
Achievement in Science and Mathematics	0.318	0.013	24.350	<0.001
Physics subject choice (Outcome)	0.484	0.019	25.205	<0.001

The results of the model for Physics subject choice presented in this section replicate the findings of Sikora (2013, 2014a) and others, with females less likely to enrol in Physics than males. An analogous procedure was followed with Biology subject choice in Year 12 as the outcome measure and is presented in Section 4.3.3.

4.3.3. Biology subject choice in Year 12

As mentioned at the start of the previous section, a similar procedure was undertaken in order to produce a model (SEM only) for Biology subject choice in Year 12. The final accepted model of Biology subject choice in Year 12 using the full sample with aggregated estimates across 20 imputed datasets suggested an adequate fit to the data (Mean $\chi2(103)=421.253$, SD=5.370, CFI=0.979, TLI=0.972, RMSEA=0.020). The standardised model is presented in Figure 4-3. Attitudinal variables have been allowed to covary due to the high correlations between them. Paths estimated in the model are significant ($p<0.05$) except where indicated in the diagram using a dashed line. These non-significant paths have been included in the model due to their theoretical interest. Standardised direct and indirect effects were estimated and are shown in Table 4-9. Unstandardised effects are available in Appendix 6.

Gender is shown to be influential in whether students enrolled in a Biology subject in Year 12, with females ($\beta=0.507$, $p<0.001$) more likely to choose Biology than males. Previous research in NSW showed that females have been consistently more likely to enrol in Biology in Year 12 than males for the past 25 years (Jaremus et al., 2018). In the present study, neither immigrant status (Native: $\beta=-0.047$, $p>0.05$) nor SES ($\beta=0.012$, $p>0.05$) are significant direct predictors. Students' attitude towards science influence their decision of whether to enrol in Biology in Year 12. If a student has a higher personal value of science ($\beta=0.182$, $p<0.001$), then they are more likely to enrol in Biology. Students who enjoy science ($\beta=0.180$, $p<0.001$) are also more likely to enrol in Biology in Year 12. Higher achievement in science and mathematics ($\beta=0.140$, $p<0.001$) is a positive predictor of a student's likelihood to enrol in a biology subject.

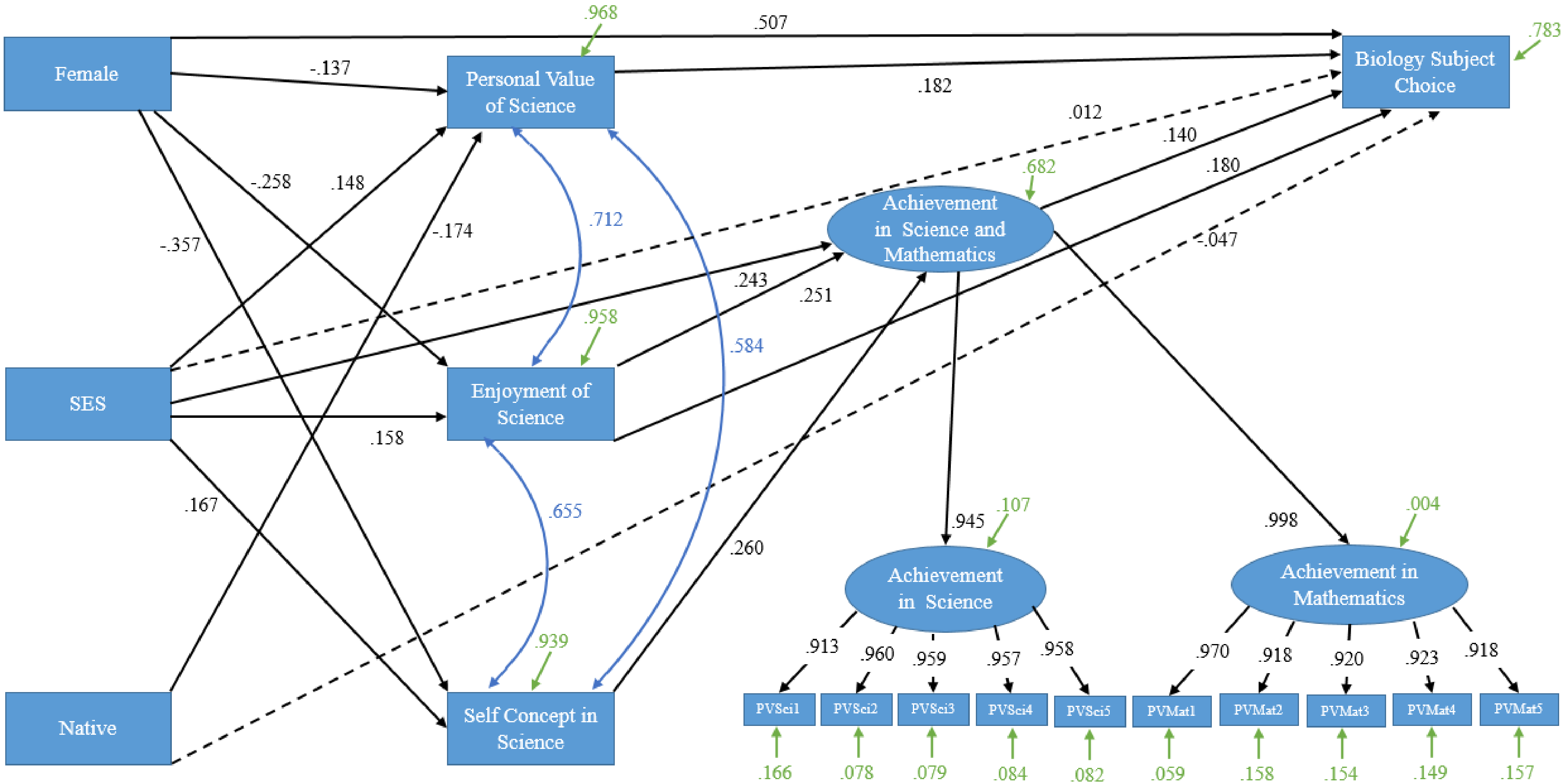

Figure 4-3. Biology subject choice model diagram (standardised).

Note. Full cohort with aggregated results of 20 imputations. Dashed lines represent non-significant paths (0.05 level). Values in green represent residual variances. Values in blue represent covariances.

Table 4-9

Direct and indirect effects on Biology subject choice (Standardised) (Pooled)

	Direct Effects				Indirect Effects				Total Effects			
	β	SE β	Z	p	β	SE β	Z	p	β	SE β	Z	p
Female - BiologySub	0.507	0.041	12.491	<0.001								
Female - EnjoySc - AchSciMat - BiologySub					-0.009	0.002	-4.205	<0.001				
Female - SlfConSc - AchSciMat - BiologySub					-0.013	0.003	-4.518	<0.001				
Female - PerValSc - BiologySub					-0.025	0.006	-4.167	<0.001				
Female - EnjoySc - BiologySub					-0.047	0.011	-4.399	<0.001				
Sum of Indirect Effects (Female to BiologySub)					-0.094	0.014	-6.752	<0.001				
Sum of Direct and Indirect Effects (Female to BiologySub)									0.413	0.042	9.798	<0.001
SES - BiologySub	0.012	0.020	0.619	0.536								
SES - AchSciMat - BiologySub					0.034	0.007	4.997	<0.001				
SES - EnjoySc - AchSciMat - BiologySub					0.006	0.001	4.478	<0.001				
SES - SlfConSc - AchSciMat - BiologySub					0.006	0.001	4.366	<0.001				
SES - PerValSc - BiologySub					0.027	0.005	5.811	<0.001				
SES - EnjoySc - BiologySub					0.028	0.005	5.632	0.001				
Sum of Indirect Effects (SES to BiologySub)					0.101	0.010	10.082	<0.001				
Sum of Direct and Indirect Effects (SES to BiologySub)									0.114	0.020	5.543	<0.001
Native - BiologySub	-0.047	0.044	-1.063	0.288								
Native - PerValSc - BiologySub					-0.032	0.008	-4.054	<0.001				
Sum of Direct and Indirect Effects (Native to BiologySub)									-0.078	0.045	-1.752	0.080
PerValSc - BiologySub	0.182	0.025	7.237	<0.001					0.182	0.025	7.237	<0.001
EnjoySc - BiologySub	0.180	0.029	6.274	<0.001								
EnjoySc - AchSciMat - BiologySub					0.035	0.007	5.102	<0.001				
Sum of Direct and Indirect Effects (EnjoySc to BiologySub)									0.215	0.027	7.976	<0.001
SlfConSc - AchSciMat - BiologySub					0.036	0.007	4.990	<0.001	0.036	0.007	4.990	<0.001
AchSciMat - BiologySub	0.140	0.026	5.327	<0.001					0.140	0.026	5.327	<0.001

The indirect effects presented in Table 4-9 suggest that there are a series of mediating relationships between students' demographic background, attitudes towards science, achievement in science, and mathematics and Biology subject choice in Year 12. The indirect effect of gender (Female: β=-*0.094, p<0.001*), mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and mathematics, is significant. The total effect of gender (Female: β=*0.413 p<0.001*) on Biology subject choice is significant. The indirect effect of immigrant status (Native: β=*-0.032, p<0.001*), mediated by personal value of science, is also significant. This results in a total non-significant effect of immigrant status (Native: β=*-0.078, p>0.05*) on Biology subject choice. SES (β=*0.101, p<0.001*) is shown to be a significant indirect predictor, mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and mathematics. The total effect of SES (β=*0.114, p<0.001*) is significant. The effect of attitudes towards science on Biology subject choice is mediated by achievement in science and mathematics. A student's enjoyment of science (β=*0.035, p<0.001*) indirectly influences whether they enrol in biology, mediated by achievement in science and mathematics. This results in a total significant effect of enjoyment of science (β=*0.215, p<0.001*) on Biology subject choice in Year 12. The indirect effect of self-concept in science (β=*0.036, p<0.001*), mediated by achievement in science and mathematics, is significant.

The proportion of explained variance (R Square) for mediating and outcome variables is shown in Table 4-10. This table shows that 21.7% of the variance in Biology subject choice can be explained by the variance of the preceding variables in the model.

Table 4-10

Proportion of explained variance (R Square) (Pooled), Biology model

	Estimate			
Construct	R^2	SE	R^2/ SE	p
Personal Value of Science	0.032	0.005	6.291	<0.001
Enjoyment in Science	0.042	0.007	5.952	<0.001
Self-Concept in Science	0.061	0.008	7.527	<0.001
Achievement in Science and Mathematics	0.318	0.013	24.325	<0.001
Biology subject choice (Outcome)	0.217	0.017	13.050	<0.001

Similar to the results of the Physics subject choice model and with those of previous research findings by Sikora (2013, 2014a) and others, females are more likely to enrol in Biology than males.

4.4. The influence of school level factors on STEM subject choice in Year 12

Results provided in this section address Data Question 3: What school level factors moderate the relationships between Year 12 students' demographic background and STEM subject choice? Following on from the student level multiple regression models and SEMs for STEM as a whole subject choice in Year 12 that were developed in Section 4.3.1. above, a multilevel multiple regression model using HLM and a multilevel SEM using Mplus were tested and results presented below.

Multilevel models for Physics and Biology subject choice in Year 12 are explored in this thesis. Previous research outlined in Chapter 2 highlighted several school level factors that may potentially influence the decisions of students entering their final year of schooling. Research by Sikora (2013, 2014a) suggested that the gender ratio of a school influences the propensity for males and females to undertake science subjects in Year 12 to varying degrees. This resulted in a variable representing the ratio of female students within a school being tested for its moderating effects on the random slopes of paths leading from demographic variables to STEM subject choice. McGaw (2006) claimed that SES may operate as a school level factor with the subject enrolment process of high and low level SES students of similar ability operating differently depending on the average SES of the school they attend. A variable measuring average school SES was included in the model and moderating paths tested. As the difference between the STEM subject enrolment decisions of native and non-native students was clear from the student level models presented above, the influence of a school's ratio of native students was of interest to the researcher. Therefore, moderating effects of a school's ratio of native to immigrant students were tested for paths from demographic variables leading to STEM subject choice. School location (metropolitan vs rural/remote) was also tested for its moderating effects on slopes.

4.4.1. STEM as a whole subject choice in Year 12

Similar to the procedure followed in Section 4.3.1., an exploratory model (multilevel) of STEM subject choice in Year 12 was first developed using HLM (see Section 4.4.1.1.). Following this, a multilevel SEM was developed (see Section 4.4.1.2.).

4.4.1.1. Multiple regression model

The final accepted student level multiple regression model (4) presented in Section 4.3.1.1. was extended to include school level variables in order to assess their moderating effects on the regression equations of STEM subject choice in Year 12 on gender and immigrant status. Again, the first imputed dataset (full sample) was used in an exploratory phase to ascertain potentially influential school level factors in the STEM subject decisions of students entering Year 12. As the multilevel multiple regression model (5) included randomly varying slopes for the regression paths of STEM subject choice on gender and immigrant status, a comparison of model fit is not assessed in relation to the multilevel multiple regression models (1-4). The results of this model are provided in Table 4-11. Unstandardised regression and standard error estimates for each predictor in the model are shown. The deviance statistic (-2 log likelihood) and significant predictors (0.05 level) are indicated in the table. Variance estimates are provided for the intercept of STEM subject choice at the school level and slopes of paths from gender and immigrant status to STEM subject choice.

Table 4-11

Multilevel multiple regression model of STEM subject choice in Year 12

	Model 5
Fixed Effect	
Intercept, γ00	0.92* (0.091)
Female, γ10	-0.13* (0.068)
RatioNat, γ11	-1.29* (0.33)
SES, γ20	0.011 (0.044)
Native, γ30	-0.49* (0.085)
SchSES, γ31	0.58* (0.12)
RatioNat, γ32	0.96* (0.31)
RatioFem, γ33	-0.45* (0.22)
EnjoySc, γ40	0.32* (0.046)
PerValSc, γ50	0.25* (0.038)
SlfConSc, γ60	0.11* (0.042)
AchSciMat (Mod), γ70	0.16* (0.0094)
Variance Estimates	
Intercept Variance, μ0	0.62*
Female Slope, μ1	0.25
Native Slope, μ2	0.011
Deviance	22,068

Note. * indicates significance ($p<0.05$). Standard error estimates in brackets.

The final accepted multilevel multiple regression model (5, see Table 4-11) replicates the findings from the student level multiple regression model (4) in relation to the effect of student level variables on STEM subject choice in Year 12. That is, demographic characteristics are shown to be influential in the STEM decisions of students entering Year 12. Gender is a significant predictor with females ($B=-0.13$, $p<0.05$) less likely to choose a STEM subject than males. The finding that SES is not a predictor of STEM subject choice ($B=0.011$, $p>0.05$) is replicated in this model. As mentioned previously, with the inclusion of other predictor variables a suppression effect may be present. It was shown in the student level SEMs that SES operates as an indirect (as opposed to a direct) predictor of STEM subject choice through interactions with other variables. Immigrant status is a significant predictor with native students ($B=-0.49$, $p<0.001$) less likely to enrol in STEM than non-native students. Attitudes towards science are shown to be significant predictors of STEM subject choice in Year 12. Enjoyment of science ($B=0.32$, $p<0.001$), personal value of science ($B=0.25$, $p<0.001$) and self-concept in science ($B=0.11$, $p<0.01$) are all significant positive predictors of STEM subject choice. Achievement in science and mathematics (B=0.16, $p<0.001$) is also a significant positive predictor in the STEM subject choice decisions of students entering Year 12.

The ratio of native students attending a school (B=-1.29, $p<0.001$) is found to be a significant negative influence on the slope of the path from gender (female) to STEM subject choice in Year 12. This finding suggests that as the ratio of native students in a school increases, the likelihood of females choosing STEM subjects decreases. The opposite effect occurs in relation to native students, with the ratio of native students (B=0.96, $p<0.01$) attending a school having a significant positive influence on the slope of the path from immigrant status (native) students to STEM subject choice. This means that as the ratio of native students in a school increases, the likelihood of native students choosing STEM subjects increases. The ratio of gender (female) (B=-0.45, $p<0.05$) within a school is found to have a significant negative effect on the slope of the path from immigrant status (native) to STEM subject choice. This finding suggests that as the ratio of female students in a school increases, the likelihood of native students choosing STEM subjects decreases. The average SES of students attending a school (B=0.58, $p<0.001$) is found to be a significant positive influence on the slope of the path from immigrant status (native) to STEM subject choice in Year 12. This means that as the average SES of a school increases, the likelihood of native students choosing STEM subjects increases. These interrelationships between gender, SES and immigrant status at both the student and school level are discussed in further detail in Sections 6.4., 6.6. and 6.10. These initial exploratory findings aid in the development of a multilevel SEM to further explore the moderation effects of school level variables on the relationships between demographic variables and STEM subject choice in Year 12.

4.4.1.2. Structural equation model

The findings presented previously, including the student level multiple regression model, student level SEM and multilevel multiple regression model, helped in the development of the multilevel SEM being presented in this section. The structure of the model's student level was a replication of the accepted student level SEM for STEM subject choice presented in Section 4.3.1. and 4.4.1. However, unlike the student level model, the variable representing achievement in science and mathematics was a single indicator scale variable computed using the mean of two plausible values

(PVSci1 and PVMaths1). The second-order latent variable of achievement in science and mathematics used in the student level model could not be used in the multilevel model due to issues of non-convergence and lack of computational processing power. This change possibly affected the relationships between variables, altering the parameter estimates of the modelled paths.

Initial generation of a multilevel model of STEM subject choice in Year 12 was conducted using a 15% sample of the first imputed dataset. After model estimation and re-specification based on statistical significance with theoretical consideration was undertaken, a final accepted model was produced. In order to test whether the final model was a more adequate fit to the data than alternative models, AIC and BIC values were used due to the models not being nested (Schreiber et al., 2006). The final accepted model produced smaller AIC and BIC values than all iterations of previously estimated models. This model was then replicated using the full sample, five sets of plausible values for achievement in science (PVSci1 to PVSci5) and mathematics (PVMaths1 to PVMaths5) across 20 imputed datasets, resulting in an aggregated model across 100 datasets. The final accepted multilevel model of STEM subject choice in Year 12 using the full sample with aggregated estimates across 100 imputed datasets produced the following fit statistics: (AIC=99485.921, SD=152.032, BIC=99721.027, SD=152.032). Paths estimated in the model are significant ($p<0.05$) except where indicated in the diagram by a dashed line. The non-significant paths have been included in the model due to their theoretical interest and the desire to replicate the student level part of the model reported above. Due to the nature of multilevel moderation and comparing effects across groups, unstandardised regression coefficients are reported. The process of standardisation takes into account the standard deviations of both the dependent and independent variables involved and those standard deviations are likely to be different across groups. In order to ensure consistency throughout this section, unstandardised regression coefficients are presented for student level paths. An unstandardised path diagram can be seen in Figure 4-4. Residual variances and standard errors are also provided in the model diagram. Indirect effects cannot be calculated for multilevel models in Mplus using Type=Random where integration is required, therefore only the direct effects are reported.

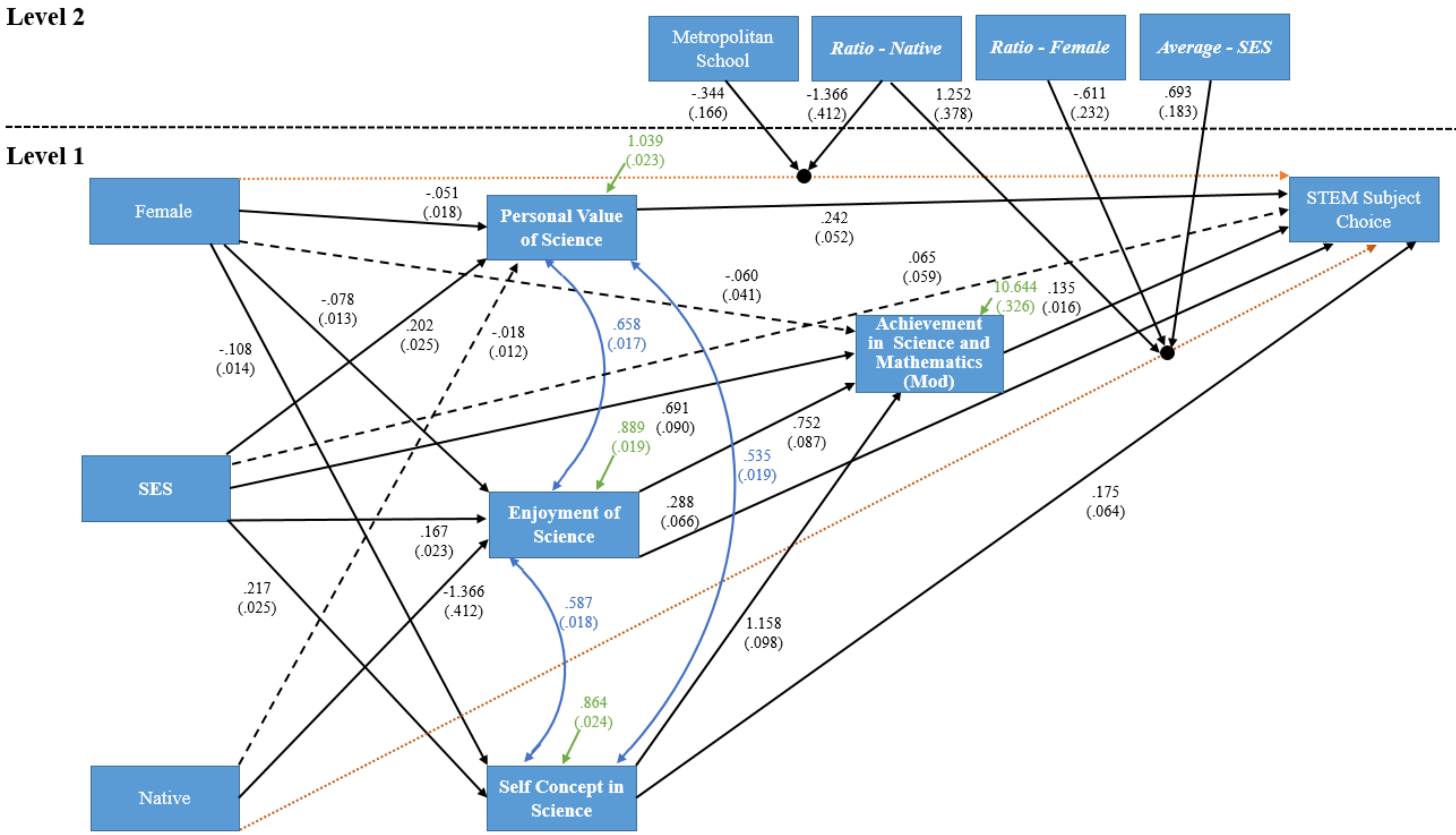

Figure 4-4. Multilevel STEM subject choice model diagram (unstandardised).

Note. Full cohort with aggregated results of 100 imputations. Dashed lines represent non-significant paths (0.05 level). Dotted lines represent paths with random slopes. Values in green represent residual variances. Values in blue represent covariances. Values in brackets represent standard errors.

As the purpose of extending the student level model for STEM subject choice to a multilevel model was to explore how school level variables moderate the relationships between student level factors, the primary focus was on the cross-level interactions. An in-depth account of the direct paths on the student level is not reported here, however it is interesting to note that the paths of significance in the multilevel model are almost the same as those reported above in the student level model. The only paths that have changed from significant to non-significant are those leading from female to achievement in science and mathematics (B=-0.060, $p>0.05$) and native to personal value of science (B=-0.018, $p>0.05$). This may be due to a suppression effect with the addition of the moderating cross-level interactions on those slopes. The construction of the 'achievement in science and mathematics' variable is different to the one computed for the student level models. Due to model complexity and convergence issues, it was not possible to include the 2^{nd} order latent variable. Therefore, a single measure was used with the model estimated and aggregated across all five plausible values for achievement in science (PVSci1 to PVSci5) and all five plausible values for achievement in mathematics (PVMaths1 to PVMaths5). This would have likely changed the way demographic, attitudinal, school and outcome variables interacted with the achievement variable within the model.

In Figure 4-4 it can be seen that the location of the school that a student is enrolled in moderates the relationship between gender and enrolment in a STEM subject in Year 12. If females attend a metropolitan school (B=-0.344, $p<0.05$) then they are less likely to enrol in a STEM subject than their counterparts in rural and remote regions. Similarly, there is a significant cross-level interaction between the ratio of native students within a school and the enrolment decisions of females within those schools. It shows that females are less likely to enrol in a STEM subject in Year 12 as the ratio of native students (B=-1.366, $p<0.01$) increases. The ratio of native students also influences the relationship between the immigrant status of a student and their decision to enrol in a STEM subject in Year 12. Native students are more likely to enrol in a STEM subject when the ratio of native students (B=1.252, $p<0.01$) within the school is increased. The gender proportion of a school is shown to be an influential factor on the enrolment decisions of native students. The ratio of females (B=-0.611, $p<0.01$) within a school negatively influences a native student's decision to enrol in a

STEM subject. Lastly, the average SES of a school (B=0.693, $p<0.001$) positively influences the enrolment decisions of native students within that school. This shows that in schools where the average SES of students within that school is high, the likelihood of native students undertaking STEM increases. These moderation effects suggest an aspirational dimension to the school context or climate. Further discussion of the effects of school type on the STEM decisions of students entering Year 12 is provided in Sections 6.4., 6.6. and 6.10.

4.5. Synthesis of results

In order to gain an overall perspective of the factors influencing the STEM enrolment decision process of students entering Year 12, a synthesis of the results from models presented in this chapter is needed. A summary of how a students' demographic background, attitudes towards science and achievement in science and mathematics influence STEM subject choice in Year 12 is presented.

Gender is shown to be an influential factor in all models presented in this chapter. Females are less likely to choose STEM as a whole than males. The differences between male and female subject choice decisions can be further elaborated by looking at the results presented in the Physics and Biology subject choice models, with females less likely than males to enrol in Physics but more likely to enrol in Biology. Not only does gender have a direct effect on subject choice but it has an indirect effect, with personal value of science, enjoyment of science, self-concept in science and achievement in science and mathematics playing mediating roles in the relationship. School level variables are shown to influence the direct effect in the multilevel model with the ratio of native students and school location having a moderating effect on the relationship. Females are less likely to enrol in a STEM subject if they attend a metropolitan school rather than a rural, regional or remote school. The likelihood of females enrolling in a STEM subject decreases as the ratio of native students in the school they attend increases.

Immigrant status influences the STEM enrolment decisions of students entering Year 12. Native students are less likely to enrol in a STEM subject than those students from migrant backgrounds. Attitudes towards science (personal value of science and enjoyment of science) and achievement in science and mathematics are significant mediators in the relationship between immigrant status and

STEM subject choice. Immigrant status is a significant predictor of Physics subject choice, with native students less likely to enrol in Physics than non-native students. Immigrant status is not a significant predictor of Biology subject choice. In the multilevel STEM subject choice model several school level variables moderate the direct relationship between immigrant status and STEM subject choice in Year 12. Native students are more likely to enrol in a STEM subject as the ratio of native students in the school they attend increases. The likelihood of a native student enrolling in a STEM subject decreases as the ratio of females within the school increases. Native students are more likely to enrol in a STEM subject as the average SES of the school they attend increases.

SES is not a significant direct predictor of subject choice in any of the models presented in this chapter. However, a significant indirect relationship is present with attitudes towards science (enjoyment of science, personal value of science and self-concept in science) and achievement in science and mathematics having a mediating influence. Through that mediated relationship, students from high SES backgrounds are more likely to enrol in a STEM subject in Year 12 than those from low SES backgrounds. This finding has implications for practice. Schools need to consider how SES influences students' engagement with STEM through various attitudinal constructs and achievement, and those influences need to be the subject of interventions to overcome low-SES disadvantage. Further, if systems want greater involvement in STEM, they need to target areas where growth can be achieved, and that includes females, native and low-SES students. Further discussion of the influence of SES on students' STEM decision making is provided in Section 6.4.

If a student has a higher personal value of science they are more likely to enrol in a STEM subject. This relationship is also present for Physics and Biology subject choice models. A student's enjoyment of science has a significant direct effect on STEM and Biology subject choice. Also, an indirect effect of enjoyment of science, mediated by achievement in science and mathematics, is present for all subject choice models. Students with higher self-concept in science are more likely to enrol in a STEM subject and Physics in Year 12. A positive significant indirect effect of self-concept in science, mediated by achievement in science and mathematics, is present for all subject choice models. Students with higher achievement in science and mathematics are more likely to enrol in a STEM subject in Year 12.

4.6. Summary

The quantitative results chapter has provided an overview of some of the identified factors that influence the STEM enrolment decisions of students entering Year 12. Combinations of direct and indirect (mediating) effects are shown to influence the decision of whether to choose a STEM subject. These include student characteristics such as gender, SES, immigrant status, personal value of science, enjoyment of science, self-concept in science, and achievement in science and mathematics. The schools that students are enrolled in are also shown to influence their enrolment decisions, with school location, ratio of females, ratio of native students and average school SES having a moderating (cross-level interaction) effect. A synthesis of these results has been provided to give an overview of the factors that influence the decisions a student goes through when deciding whether or not to enrol in a STEM subject in Year 12.

5. QUALITATIVE RESULTS

5.1. Introduction

In this chapter, the findings from the qualitative phase of the research are presented to address Research Question 2 “How do background variables influence beliefs about STEM, intention towards STEM and enrolment in STEM subjects in Year 12?” This includes a profile of the participants involved in the qualitative phase, including information relating to their demographic backgrounds (gender, self and parent(s)/caregiver(s) country of birth, parent(s)/caregiver(s) education and occupation), the schools they attended (sector, location, SES, size, gender mix) and STEM subject choice in Year 11 and 12. A student’s profile provides the context through which excerpts from their transcripts, as they relate to the theme being addressed, can be viewed. The remainder of the chapter is organised under issues that identified in the quantitative phase and themes that emerged from the students who were interviewed and were consistent with the over-arching conceptual framework – the theory of planned behaviour (TPB). It needs to be made clear that the interview questions that resulted in the following findings were aligned with the elements outlined in the TPB and the quantitative results from Chapter 4. The findings in this chapter are either consistent with the quantitative results or existing elements of the TPB, or extend those elements. However the purpose of this research was not to validate the TPB using data that arose from the interviews. In fact, some of the perspectives explored in this chapter were not predicted by the TPB and extend the model beyond what has previously existed. Section 6.2. outlines the contribution that the adapted TPB model made in this research and how the findings from this phase, along with those presented in Chapter 4, required a re-conceptualisation of the adapted TPB.

The first overarching issue investigated is the relationship between a student’s intention to enrol in a STEM subject in Year 12 and their subsequent enrolment (see Section 5.3.). The second issue is the extent to which their attitude towards STEM influences STEM enrolment, including a discussion of sub themes relating to enjoyment, interest and motivation, self-efficacy, identity and affinity with STEM, the perceived nature of STEM, reward for effort in STEM, perceived difficulty of STEM, and personal and societal value of STEM (see Section 5.4.). The third overarching issue is the perceived norm for STEM and explores students' perceptions of what others think they should do in relation to their STEM subject choice decisions in Year 12 (see Section 5.5). This section includes a discussion of the influence of parent(s)/caregiver(s), classroom teachers and peers and the extent to which they are influenced by those normative views. The fourth overarching issue is students' perceptions of how much control they have over their decision of whether to enrol in STEM subjects in Year 12 (see Section 5.6). The fifth overarching issue is how a number of background factors influence a student's STEM subject choice decisions as they prepare for Year 12 (see Section 5.7). Factors explored in this section include education and career requirements, gender identity, altruism, wonder and past experiences, the educational level and occupation of parent(s)/caregiver(s), school context, prior achievement in STEM, teacher quality and STEM exposure outside of the classroom. Several of the findings presented are consistent with the results outlined in Chapter 4, including the influence of gender, SES, immigrant status, value of STEM, enjoyment of STEM, self-concept in STEM, achievement in STEM, and school type and context. A number of other issues were raised in interviews but only those determined to be of most importance are included in this chapter. A summary of the findings is presented in the final section of the chapter. This chapter presents the findings, with further discussion offered in Chapter 6.

5.2. Profile of participants

In this phase of the research, 20 students entering Year 12 in South Australia were interviewed regarding their subject choice decisions and the potential factors that influenced them during this time. The sample consisted of 9 males and 11 females who were all enrolled in at least one STEM subject in Year 11. All students are required to enrol in a least one semester of a Year 11 or 12 mathematics subject in order to satisfy the numeracy requirements of the South Australian Certificate of Education (SACE) (SACE Board of South Australia, 2018). Although students are not required to enrol in a mathematics subject classified as STEM in this research, i.e. intermediate (Mathematical Methods) or advanced (Specialist Mathematics), the compulsory aspect of SACE requirements increases the likelihood that they would enrol in a STEM subject in Year 11. Another compulsory SACE requirement is that subjects equating to six semesters must be completed at Year 12 level, meaning that a remaining nine semesters worth of subjects can be completed at Year 11 (SACE Board of South Australia, 2018), thus increasing the likelihood of STEM enrolment at Year 11. An overview of the schools involved in the qualitative phase of this research is provided in Table 5-1, and includes the school sector, location, average SES, size and location for each.

Table 5-1

Summary of characteristics of schools involved in the qualitative phase of the research

School ID	School Sector	School Location	School SES	School Size	School Gender
1	Public	Regional	Low	Large	Co-Educational
2	Public	Metro	High	Large	Co-Educational
3	Private	Metro	High	Large	All Girls
4	Public	Rural	Medium	Small	Co-Educational
5	Public	Metro	Low	Large	Co-Educational

An overview of the participants involved in the qualitative phase of this research is given in Table 5-2. Participants' pseudonyms, school, gender, country/region of birth, parent(s)/caregiver(s) country/region of birth, parent(s)/caregiver(s) occupational area, and parent(s)/caregiver(s) highest level of education are provided. In order to protect the anonymity of participants some of the information provided on the screening tool used for participant recruitment was altered. For country of birth and parents' country of birth, specific countries outside of Australia were replaced with information about the region instead. Also, as parents' specific job titles were given, particular students could be identified. Therefore, parents' occupations have been coded using the Australian and New Zealand Standard Classification of Occupation (ANZSCO Version 1.2). The first two digits of the ANZSCO coding are provided in the table, which also details the major group (managers, professionals, technicians etc.) and the sub-major group which states the field in which they worked (Education, Health, Engineering etc.). An overview of the ANZSCO codes and the fields of occupation information are provided in Appendix 7. STEM enrolment information for both Year 11 and 12 is provided. In all, 20 participants (M:9, F:11) were involved in the interviews of whom 14 were native students (both parents born in Australia) and 6 non-native students (at least one parent born overseas). Fifteen of the participants had at least one parent who was working in either a managerial or professional occupation. Twelve participants had at least one parent who completed a university level qualification. Of the 20 participants involved in this research, 15 went on to study at least one STEM subject in Year 12.

Table 5-2

Characteristics of participants involved in the qualitative phase of the research

Pseudonym	Gender	Country/Region of Birth	Father Country/Region of Birth	Mother Country/Region of Birth	Mother's Job	Father's Job	Mother's Highest Level of Education	Father's Highest Level of Education	STEM Subject(s) in Year 11	STEM Subject(s) in Year 12
1 - Zac	Male	Australia	Australia	Australia	52	27	Year 12	Year 10/11 and TAFE	Yes	No
2 - Alana	Female	Australia	Australia	Australia	59	23	University	University	Yes	Yes
3 - Samuel	Male	Australia	Western Europe	Australia	51	25	University	University	Yes	Yes
4 - Emily	Female	Australia	Australia	Australia	43	13	Year 10/11 and TAFE	Year 10	Yes	Yes
5 - Luke	Male	Australia	Australia	Australia	24	23	University	University	Yes	Yes
6 - Anna	Female	Eastern Europe	Eastern Europe	Eastern Europe	25	11	University	University	Yes	Yes
7 - Jessica	Female	Australia	Western Europe	Australia	11	73	Year 10	Year 10	Yes	Yes
8 - Brodie	Male	Western Europe	Western Europe	Western Europe	24	23	University	University	Yes	Yes
9 - Edward	Male	Australia	Western Europe	Western Europe	22	31	Year 12 and TAFE	University	Yes	Yes
10 - Scarlett	Female	Australia	Australia	Australia	42	59	Year 12	Year 10/11 and TAFE	Yes	Yes
11 - Lily	Female	Australia	Western Europe	Australia	61	61	Year 10	Year 12	Yes	No
12 - Suchitra	Female	Asia	Asia	Asia	13	13	Year 12	University	Yes	Yes
13 - Eliza	Female	Australia	Australia	Australia	25	12	Year 10/11 and TAFE	Year 10/11 and TAFE	Yes	No
14 - Dylan	Male	Australia	Australia	Australia	61	23	Year 12 and TAFE	University	Yes	No
15 - Hayden	Male	Australia	Australia	Australia	62	33	Year 10/11 and TAFE	Year 10/11 and TAFE	Yes	Yes
16 - Tahlia	Female	Australia	Australia	Australia	42	31	University	Year 10	Yes	Yes
17 - Arun	Male	Asia	Asia	Asia	83	13	University	University	Yes	No
18 - Claudia	Female	Australia	[Missing]	Australia	22	[Missing]	University	N/A	Yes	Yes
19 - Keira	Female	Africa	Africa	Africa	27	23	University	University	Yes	Yes
20 - Cooper	Male	Australia	Western Europe	Australia	62	71	Year 10	Year 12	Yes	Yes

Note. Detailed information on participants and parents country/region of birth and parents occupations collected and informed analyses, but in order to preserve students' anonymity, aggregated data are used in the table.

5.3. Intention to enrol in STEM

The relationship between an individual's intention to enact a behaviour and subsequent execution of that behaviour has been described in the TPB framework (Fishbein & Ajzen, 2010). According to this theory, an individual will perform a behaviour if they have an intention to do so and have sufficient *actual* control over the decision (Ajzen & Albarracin, 2007). In this research, the intention to enrol in a Year 12 subject is formed by the student who generates a list of preferred subjects going into their Year 12 subject selection meeting. It is common for South Australian schools to ask students towards the end of Year 11 to complete a subject selection form, outlining their preferred subjects and backup subjects for Year 12. Students bring their subject selection form to a meeting with school staff (including subject counsellor, year level coordinator) to discuss their choices. In relation to the TPB, behaviour is their actual enrolment in Year 12 subjects following this subject selection meeting. As copies of their intention (subject selection) lists could not be accessed, the following question was asked to ascertain whether they enrolled in the subjects they intended to before the subject selection meeting: "Going in to your subject selection meeting, did you select the subjects for Year 12 that you originally intended to?" Initial responses and their elaborations after further questioning elicited sufficient information to allow the researcher to determine whether the relationship between intention and behaviour existed. Twelve of the 20 participants involved in this research enrolled in the subjects they had intended to take during their Year 12 subject selection meetings. For the 12 participants who enrolled in the subjects they originally intended to, their explanations for 'why' are typically straight forward, like Alana who states:

> *I'd written out before I went into the meeting what I was going to do [..] they went "yeah, that's all good" and wrote it all down and you know, there wasn't anything that changed during the subject selection meeting.*

However, eight of the participating students did not behave the way they had originally intended, suggesting that there were potential influencing factors that affected their decisions.

Emily had an adequate range of subjects to choose from coming from a large regional school, but some uncertainty around university course pre-requisites made her change her mind during the subject selection meeting:

> *I didn't intend to do Nutrition, I intended to do math instead. But then [..] I talked with the two people [..] that I was interviewing with and [..] I thought that [..] math was a prerequisite to get into university, cos you know how they say that [..] Year 12 English [..], you have to have passed [..] to get into uni. I thought it was the same with math. And so I chose that, but then I found out that I didn't have to, so I chose Nutrition instead.*

A simple misunderstanding like this can be rectified in the subject selection meeting with school staff who have the knowledge and access to information about post-school education and career pathways. Also, in Section 5.4.8. Emily indicates the potential reasons for disengaging with mathematics are due to her perception that some of the content taught in mathematics classes is useless in the 'real world'. For many of the other students who did not enrol in the subject they originally intended to, the case was a little more complex.

Interestingly, all four students from the small regional school enrolled in a Year 12 subject that they did not intend to when going into their Year 12 subject selection meeting. Some of the students from this school did not have *actual* control over their decisions due to school related constraints, such as student enrolment numbers, inadequate staffing, timetable structures and vertical classes (two year levels combined). These constraints are discussed further in Section 5.7.5. Although this finding cannot be generalised to all students attending small regional schools, it does highlight a unique set of barriers to subject selection entering Year 12. Some of the constraints and barriers that affected these students' decisions are explored further in subsequent sections of this chapter.

5.4. Attitude towards STEM

In this chapter, participants discussed how their *enjoyment* of STEM subjects in earlier years of schooling influenced the decisions they made relating to the subjects they enrolled in for Year 12 (see Section 5.4.1.). A student's *interest* in a STEM subject can ultimately impact their *motivation* to continue pursuing that to higher levels of education and in subsequent careers (see Section 5.4.2.). A student's *self-efficacy* for a STEM subject emerges from prior experience with the subject (see

Section 5.4.3.). Those experiences may include prior achievement and teacher dis/encouragement. A natural affinity or inclination for STEM was identified as participants discussed the concept of '*self*' (see Section 5.4.4.). The structure of STEM subjects, how they are taught in schools and the underlying *nature* of STEM as predictors of future enrolment are explored (see Section 5.4.5.). The relationship between the level of effort required to achieve at a high level in STEM subjects and the resultant *reward* in the form of satisfaction is clear from the participant's responses (see Section 5.4.6.). Some participants described how prior performance and the *perceived difficulty* of continuing to pursue STEM subjects at a higher level was too much pressure or required too much time and effort (see Section 5.4.7.). The *value* that participants within this cohort placed on the applications of STEM and how they related to both their everyday lives and to society as a whole, highlights the importance they placed on STEM education (see Sections 5.4.8. and 5.4.9.). These sub-themes are addressed in the remainder of the section.

5.4.1. Enjoyment of STEM

The opening question in interviews with all participants in this phase of the research was "How did you come to the decision to choose your subjects for Year 12?" One of the most commonly given reasons for choosing a subject in response to this broad question was enjoyment of the subject. Many participants provided brief but clear statements regarding the relationship between enjoyment of a subject and subsequent enrolment in that subject, as Alana did when she stated "the biggest influence was definitely that I enjoyed doing the subjects". Whether a student enjoyed a subject is commonly linked to other motivational factors such as boredom and performance. Lily described this relationship in the following way:

> *It would definitely be [..] what I enjoy. I tried to really consider that. Because I don't want to be, doing something I'm not completely happy with or [..] I find really boring. Cos I feel like then I'd do worse in the subject.*

In this excerpt, Lily clearly describes how enjoyment of a subject impacts her concentration levels due to boredom. If she finds herself getting bored in a subject then that will likely affect her performance in that subject. This suggests that she also has a performance goal orientation, where enjoyment likely influences the level to which she reaches the desired performance. However, it is unclear whether the performance goal is more important than enjoyment or simply a by-product. In contrast, the lack of enjoyment in a subject can have the alternative result with students being less likely to enrol in a subject. Scarlett highlighted this point:

> *Probably what I enjoy the most. And now into Year 12, I'm not going to do a subject that I don't enjoy, really. Like, I'm really good at maths and I've been recommended to do Specialist Maths, cos I'm getting As and I can do and get As but I don't enjoy it so, I'm not going to do it.*

This is a clear illustration that although she had high self-efficacy in mathematics and would likely achieve at a high level, the lack of enjoyment in the subject carried more weight than likely achievement in the decision-making process. Enjoyment of the subject is clearly the primary objective, with performance a secondary one.

5.4.2. Interest and motivation in STEM

The motivation for a student to continue participating in a subject is influenced by their interest in or curiosity with the concepts covered in topics within the subject or a general interest in the subject as a whole. When Alana started describing why she enjoyed certain subjects she talked about doing STEM experiments at home and how that influenced her perception of them, stating "I suppose it's fuelling curiosity and how things work and yeah, the interest I have in those kind of things … I've always been interested in science type subjects." The relationship between interest in the subject and the increased motivation to continue participating in that subject was described by Samuel, explaining "It's something that [..] interests me and I'm really motivated by my interests and it's something that I will [..] keep pursuing." This further highlights the importance of developing an interest in a subject in order to increase motivation within that subject. The lack of interest in a subject can have the opposite effect with students who lose interest in a particular subject less likely to continue participating in it. Arun was quite clear in his thinking around interest and participation stating simply:

> *I'm not interested in science in any kind of way [..] I found maths more interesting and science, I didn't share any interest in it [..] I'm not going to be doing a subject which I have no interest in.*

Adding further to these ideas was Eliza, who described how the lack of interest that developed over the years resulted in her not studying any STEM subjects in Year 12:

> *It might be the way that the teacher teaches it. It might be just it's not as interesting as it used to be, cos when you're doing science in the lower years [..] it's a lot more diverse and you get a range, you get a look at all of them because it's just science, there's no specifics, but then when you go into the specific ones [..] I just kind of lost interest because it didn't seem as interesting as it used to.*

This excerpt provides an account of a student who was influenced by both curriculum content and the pedagogical nature of the classroom. Many of the factors that influence a student's decision of whether or not to enrol in a subject during Year 12, including interest and motivation for the subject, seems to develop throughout all years of schooling and adds to the complex nature of the decision-making process.

5.4.3. Self-efficacy in STEM

A student's self-efficacy in STEM subjects is shown to be influential in the subject selection process with participants often reporting that ability in a subject, due to prior experience, is linked with expected future achievement in the subject. Tahlia described her thinking by saying "I mostly did [Mathematical Methods] for next year because I thought I was good at it and knew that I could get a decent grade." Cooper provided a further indication of a participant's high level of self-efficacy resulting in a decision to continue in the subject. He had the perception that a lower level subject would be too easy, increasing the motivation to pursue a more challenging subject:

> *Maths is something that I find a little bit easier than other subjects and I'm quite good at it, so I thought I might as well just keep going with [Mathematical Methods] and keep doing that level of maths. Because I, I feel like [General Mathematics] may not push me enough.*

If a student develops a high level of self-efficacy in a STEM subject, the likely result is a perception of finding the subject easier and increased expectation of grades. This combination of factors seems to increase the likelihood of a student enrolling in that subject in Year 12. The counter example is also evident with some participants showing low levels of self-efficacy in a STEM subject, leading them to discontinue with the subject past Year 11. Lily described her experience with Chemistry in Year 11 and her lack of understanding saying "so I only did [..] a term of Chemistry and then I never did it again [..] I just remember not understanding it at all." Another indication of a lack of understanding and the resultant low level of self-efficacy in a STEM subject was provided by Eliza, where she stated "I used to really love maths and algebra but this year, doing Maths Methods [..] it got really difficult to the point where I just wasn't enjoying it cos I didn't understand it." Although she had previously enjoyed participating in the subject, her decreasing level of understanding in the subject resulted in decreased enjoyment and subsequent non-participation in the subject at Year 12.

5.4.4. Identity and affinity with STEM

A student's identity and affinity with STEM is a complex and multi-faceted construct that likely develops over many years and is influenced by a number of different factors. Some participants in this research discussed aspects relating to their concept of 'self' in an introspective way. Alana described how she considered the influence of 'others' on her decision-making process whilst ultimately making the decision for herself:

> *I suppose it's a part of wanting to be different [..] there are all these people and things that can try and tell you who to be but [..] you've got to look at what you want and how you want to get there and I suppose be strong in what you believe. [..] not be swayed from your [..] path so I suppose I have a vision of who I am and who I want to be and how I'm going to get there and even though other people can say other stuff, I can either choose to take it on board or choose to ignore it [..] at the end of that you're still making your decisions.*

Alana discussed the role that others can play in the formation of intentions but she was quite clear in her thinking, recognising what her concept of 'self' was and how important it was to acknowledge that when making the decision of what subjects to choose in Year 12. In this extract, she provided an idea of her perception of identity and affinity with STEM thus providing "answers to the basic questions "Who am I?", "Where do I belong?", and "How do I fit (or fit in)?"" (Oyserman, 2001, p. 499). Claudia highlighted more extrinsic aspects of identity and affinity with STEM by embracing the 'smart' complex that is associated with studying STEM, remarking "I feel a little bit smarter by studying [STEM subjects]. Because they're not considered as easy for everyone. Like, you get called a nerd a lot, but it is enjoyable to learn." This excerpt provides an example of how Claudia experienced being called a nerd, but embraced it as she enjoyed adopting the concept of a 'smart self', due to the perceived difficulty of STEM subjects. Keira provided evidence of an introspective account of herself as naturally inclined towards STEM, describing how she chose her subjects in the subject selection meeting by saying “I told [subject counsellor] that since I’m a science-oriented student, I think probably I might want to do Maths, Chemistry, Biology and Physics.” Whether or not a student’s identity and affinity with STEM are due to a holistic vision of ‘self’, a ‘smart’ complex, or science orientation, the influence of ‘self’ on the decision-making process is clear.

5.4.5. Nature of STEM

The underlying nature of STEM and topics covered in STEM subjects was explicitly and implicitly referred to in discussions with participants in this phase of the research. The concept of a definitive answer in STEM subjects, as opposed to subjective answers that are more often associated with non-STEM subjects, is shown to influence the educational pathways of students. Brodie, who had chosen to undertake Chemistry, Physics, Mathematical Methods and Specialist Mathematics in Year 12, discussed the nature of STEM and his natural affinity for the type of thinking and problem solving involved in STEM:

> *… having like a physical defined solution for something, so you know, given a problem [..] there are a few ways of going about it, but you’re always going to get within a definite answer. And sort of given a problem, it can be solved. And solving it, I find very rewarding.*

Brodie’s response to his enjoyment of STEM subjects and being able to find a definitive solution to problems spoke to her perception of the nature of STEM subjects and its influence on the decision-making process. The idea of certainty and lack of ambiguity associated with sciences and mathematics likely leads to the notion of solutions being definitive. Keira further elaborated on her perception of the nature of STEM and the power of being able to study subjects that have definitive solutions:

> *I thought that it will be good if I did sciences cos sciences are the same throughout and I’m a science-oriented student and not an art student so for me doing sciences, it’s easy cos it’s not, I’m not going to struggle when doing them … Wherever you go in the world, sciences are the same, they never change, cos they are based on true facts.*

This excerpt from Keira provides evidence of her perception of the nature of STEM subjects being consistent throughout the world, coming from the unique circumstance of her recently emigrating from Africa. Whether the use of the term ‘true’ facts can be attributed to language or not, it shows that the concept of a defined solution was important to her. These findings are complementary to those discussed briefly in relation to the influence of curriculum content and pedagogy on Eliza's subject choice decisions (see Section 5.4.2.).

In an alternative way, the perceptions of the underlying nature of STEM subjects can have a negative influence on a student's desire to continue choosing STEM subjects throughout their schooling. Eliza was undertaking Year 11 Chemistry, Biology and Mathematical Methods at the time of the interview but chose not to enrol in them for Year 12. She pointed to the changing nature and structure of activities that are done in these subjects through the years as the reason for not continuing with them to Year 12:

> *When you're doing science in the lower years [..] it's a lot more diverse and you get a range, you get a look at all of them because it's just science, there's no specifics, but then when you go into the specific ones [..] I just kind of lost interest because it didn't seem as interesting as it used to … Chemistry it's more bookwork and a few experiments here and there, but it's about learning all the equations and all the different things with that, which links heavily into maths a lot of time.*

The changing structure of STEM subjects resulted in Eliza losing interest in them. She referred to the formation of STEM 'silos' where science is split into individual disciplines as a reason for losing interest as well as the types of activities that are typically done in class. Eliza further elaborated on the types of activities that she preferred, stating "I have to be able to do something with my hands to learn. I can't learn out of a book. Which is a lot of what we do here is just learning out of textbooks." Many examples are provided throughout the transcripts of participants discussing the desire for a hands-on approach to STEM as a means of increasing interest in subjects. Examples of the influence of the changing nature of STEM subjects as students progress through school, in relation to both the content covered in topics and the pedagogical approach of many STEM teachers, is clearly evident thus far. The influence of students' classroom experiences with STEM teaching and learning on STEM subject choice is discussed in more detail in Section 6.9.

5.4.6. STEM is rewarding

The feeling of an intrinsic reward as a motivating factor to continue to pursue a subject was described by Cooper (Section 5.4.3.). Further examples of the rewarding nature of undertaking and achieving at a high level in STEM subjects were provided by other participants within the research. Samuel made a clear link between the effort that is required to achieve a good grade in mathematics and the feeling of reward that comes with it as a motivating factor:

> *I think with maths it's more the sense of accomplishing something and being able to have something to show for the effort … So being able to achieve an alright grade by putting in the effort and, cos it's definitely a struggle, it doesn't come naturally to me at all. I definitely put in a fair amount of effort and I like the reward that comes with that, when I get a test back or folio back.*

The combination of an intrinsic reward through the feeling of accomplishment coupled with the extrinsic reward of a high grade was clearly an influence in his continued enjoyment of and enrolment in STEM subjects. Like Cooper, Brodie outlined the reward that comes with solving problems in mathematics, but contextualised it in the classroom setting and the effect it had on the class as a whole by stating "Specialist Mathematics especially [..] you feel rewarded because as a class [..] you're solving these problems that you probably didn't feel you could solve on your own. Which ah, makes it very rewarding for the whole class". Brodie acknowledged the difficult nature of concepts in STEM and the benefit of working with peers to solve a problem, and the resulting reward. He added to his argument about the rewarding nature of STEM with a statement about his future career aspirations, suggesting "I've always been brought up in this sort of environment where STEM is really the only really rewarding career, so that's definitely what's led me to choose it." A further exploration of career aspirations and their influence on whether a student chooses a STEM subject in Year 12 is explored in Section 5.7.1.

5.4.7. Perceived difficulty of STEM

The perception of a subject being too difficult to undertake is often given as a reason for not pursuing it in Year 12. This is due mainly to previous experiences with the subject in Year 11 or the increased difficulty of topics covered in the subject in Year 12. Jessica was undertaking Chemistry, Biology, Mathematical Methods and Specialist Mathematics in Year 11 and was hoping to continue with them in Year 12. However, the perceived difficulty of the subject led her to drop one of them and enrol in English instead, rationalising:

> *I just thought English would be like an easier subject so I could like, mainly focus on my main three, which is Chem, Methods and Spec, and then just have English as just like another subject which I can like, get ahead in and then just mainly put all my time and effort into those main three.*

Even though she had considered overloading her subject load in Year 12 so that she could continue with Biology, she had ultimately decided to drop a STEM subject for one that she considered to be easier. The idea of the increased workload being associated with studying STEM subjects has led many students to drop them for Year 12. Edward was undertaking four STEM subjects in Year 11 and achieving at a high level (A grade) in all of them, but decided to drop Chemistry due to the perceived workload:

> *… more just the workload, because I know in Year 12 everything gets stepped up. So I just thought, well, if I drop Chemistry I'll have a lot of free time and I can make sure that I get As throughout.*

This same notion led Arun to discontinue studying STEM subjects completely:

> *Oh, due to work overload as well. Because Spec Maths has a lot of work, and a lot of ah, topics that we have to cover. If I were doing ah, Spec Maths and Methods, that means I would have two exams, and that was a lot of challenge.*

The perceived difficulty and increased workload of studying STEM subjects in Year 12 has led many students to either drop a STEM subject or discontinue with STEM altogether. If a subject is perceived to be difficult, typically based on prior achievement and advice from others, then students may develop a perception of how hard they will need to work in order to achieve an adequate result. This perception induces the students to consider how much they value STEM and whether continued enrolment in a subject is worth the perceived cost in terms of more effort and potential grades. The idea of weighing up the utility value versus relative cost was previously described by Lyons and Quinn (2010) (see Sections 2.5.5.5. and 6.8.). Some consideration for the potential influence of publicly assessed examinations on students' perceptions of cost is outlined in recommendations for future research (see Section 7.4.).

5.4.8. Personal value of STEM

Knowledge gained through studying STEM subjects and its applicability in students' daily lives leads to a formation of particular personal values that they place on it. Many participants highlighted the importance of STEM in their daily lives and the generic skills that are developed through studying STEM subjects. Arun pointed to the importance of STEM skills for post-school life, noting "STEM is really important … especially when it comes to maths. It gives you … a background knowledge of how you can basically manage your life when you graduate." Others discussed the idea of improving their problem-solving ability and developing an interest in finding out 'how things work' through studying STEM. Jessica argued "Even though people say you won't need this in your life [..] it can help you figure out a lot of questions and it also increases your problem-solving skills", while Brodie stated "I think it develops that sort of critical thinking and analysis, and ah, problem-solving." Alana added "I find it to be valuable in my personal everyday life [..] it helps me to learn new things and yeah, explore the world around me and how it works." At times, students may not see the usefulness of topics covered in their STEM subjects, particularly the applicability of them to their daily lives. Dylan was studying Psych in Year 11 but dropped it for Year 12, and discussed his experience of the applicability of STEM in a regional setting:

> *Anything I've learnt in a STEM class, I haven't really used outside of school. Or think I'll ever use … It's because I can't really relate it anything outside of school or interest, I just haven't seen the point in going through it.*

The lack of personal value of STEM in a small regional setting may be of significant influence as Eliza also described, stating "not at the moment cos I don't really do much, just working on the farm, it's just working with sheep that I normally help with. So I don't really use a lot of it, really." Emily, who also came from a regional setting described in detail the perceived lack of usefulness of mathematics in particular:

> *Like some things in math, you're not really ever going to use again … Oh, like algebra. [Laughter] I really like it, but I don't really understand why we do it … Because like, now I feel like they give you all the answers already. Like, you don't need to figure out your shopping because somebody does that for you [..] we're doing linear functions at the moment and I have no idea why we're doing it [..] I feel like it's a bit irrelevant … It's kind of like, "oh this is what we're learning and just do it because we're learning". Like they don't really explain like, "oh this is how you could use it in everyday life" and I feel like that would be more important.*

The level of disconnect many students see between topics and concepts covered in STEM subjects and their application to problems faced outside of school is clear. If students are going to invest their time into studying a subject in Year 12 they need to be able to see the value of its application in their everyday lives.

5.4.9. Societal value of STEM

Whilst discussing the value of STEM in their personal everyday lives, participants also described the societal value of STEM. Although some found it hard to articulate its value for society as a whole, they often pointed to the nature of a rapidly changing world due to the increase in technology as a reason for concern. Eliza stated "It's very important. Because without scientists and people actually understanding things and how to do it, we can't really move forward. We're sort of stuck where we are with what we understand". The idea of needing to keep moving forward and advancing was substantiated by Alana who talked to the technologically advancing industries and the careers that are likely to develop as a result of this:

> *Well, with the world moving to like, computers and robots running everything [..] I think it takes a lot of science and engineering knowledge to make and program these things [..] I think that STEM is important in the real world because of our advancing technology. And it's important for people to know how to do that stuff so that they can work in those industries.*

The industries that have developed and the nature of work related to STEM has seen rapid change throughout history (Schwab, 2017). Edward discussed this and the reason to be careful of the power of STEM:

> *I think it's very valuable. We wouldn't be here today without it [..] the living conditions have risen once STEM subjects became more of the norm, back in the Industrial Revolution when you started getting the steam engines and everything, everything's just risen. Although it has caused some other problems, like climate change [..] hopefully we can engineer our way out of that.*

In this excerpt Edward saw applications of STEM as both extremely useful but dangerous at the same time. He seemed to remain confident though that advancement of STEM industries will be able to overcome issues relating to advancing technology and its adverse effects on the environment.

5.4.10. Attitudes towards STEM: a summary

In summary, past experiences with STEM education influence students' attitudes towards STEM. Students' perceptions of the content typically covered in STEM in the later years of schooling and the pedagogical approach taken by STEM teachers had on effect on their level of enjoyment, interest and motivation in STEM. The definitive nature of STEM subjects and the view of seeing success in

STEM subjects as an intrinsic reward, was how some participants overcame some of the negative perceptions of STEM. As a result of these experiences and resultant attitudes towards STEM, students can develop a positive (or negative) identity and affinity with STEM. The development of this identity or view of 'self' and future utility influences the value they place on STEM education and careers and ultimately the decision of whether to enrol in a STEM subject in Year 12.

5.5. Perceived norm

The perceived norm as it relates to STEM subject choice in Year 12 is a student's perception of what they believe others in their social circle think they should enrol in (Fishbein & Ajzen, 2010). Perceived norm, like attitude, is formed from a set of beliefs about what they think individuals or groups close to them may want them to do. *Parent(s)/caregiver(s)* are one of the most commonly mentioned people who exert varying levels of influence, altering participants' normative beliefs (see Section 5.5.1.). Previous experience with and discussions with classroom *teachers* can also influence a student's normative beliefs (see Section 5.5.2.). The enrolment intentions of and interactions with *peers* can affect the way students view STEM subjects and their subsequent enrolment plans going into Year 12 (see Section 5.5.3.). These constructs are explored in the following sections.

5.5.1. Parent(s)/caregiver(s) influence

The influence of a parent(s)/caregiver(s) on a student's decision-making process going into subject selection for Year 12 is clear. Whether it is a direct or indirect effect, parent(s)/caregiver(s) were often discussed throughout the interviews as sources of advice or barriers to control over participants' decisions. The range of influence throughout the sample varied from little or no influence to significant influence where participants felt they had to change their educational and future career pathways as a result. Hayden described a common response from parents, saying "They didn't mind what I did with it, they were happy with whatever I chose." Cooper also felt little pressure from his parents, highlighting "I know what's best, like I know what I enjoy. So they kind of let me pick what subjects I want to do [..] they're cool about it." Many students discussed how their parent(s)/caregiver(s) were happy for them to choose the subjects they wanted to as long as they had a clear end goal in mind and the subjects chosen would satisfy any post-school requirements.

Some students received advice that could have been perceived as confusing, offering suggestions but also stating that the decision was theirs alone. Emily outlined her experience with her mother and the changing nature of these conversations:

> *Yeah, it's kinda hard because I ask for advice sometimes like "oh, I don't know what to do" and she goes "oh, oh well you do what you want" but then other times she tells me like, exactly what to do … My dad's a bit clueless when it comes to schooling and stuff so he doesn't really have a say. He says "as long as you're happy" … they want me to be happy and they want me to strive and to like, keep going forwards [..] But then like, on the other hand, they're like "oh you can drop out in Year 12 if you want". [Laughter] Like, they don't really mind.*

Emily appeared to be confused about the advice she was receiving from her parents. The laughter at the end of this excerpt is indicative of contradictory feelings about what her parents wanted her to do. The lack of clear and considered advice received by Emily from her parents may indicate that her parents did not have an adequate understanding of the variety of post school pathways open to her and the subjects needed to pursue that pathway. This lack of understanding on her parents' behalf may have been a result of their level of education, with neither completing Year 12 studies. The influence of parent(s)/caregiver(s) level of education is explored in more detail in Sections 5.7.4. and 6.4. Arun discussed at length the role his parents played in helping him to decide on his educational and career pathway. He too received varied advice about what subjects to choose in Year 12:

> *I was like "oh Mum, do you think I should be doing Psychology or Modern History?" and she was like "what do you think will help you, or just not helping you, what do you think you'll have fun? Cos if you don't have fun in the subject, there's no point, because you won't be that interested and determined to succeed". So I ask my dad, he was like "yeah, do what you feel the most comfortable with and we'll support you" … Like, they'll have a look, like, they get the final say. I'll give mother like, "here Mum, that's what I think I want to do, can you have a look". And she's like "yeah, I think that's good" but she'll give me suggestions. She'll be like, "you should not have that". Then she will give me a big talk about like, that's going to be bad for you in that future and why … They will be like, "that's fine, but you have to put in the effort". That's all they care about. They don't really care about what subjects I'm doing, as long as I'm going to be a successful person in life. In life, you can do anything, but whatever you do, you have to be good at it. And you do need to put in the effort.*

Arun shared many stories throughout the interview about his discussions with family members, in particular his parents and their desire for him to succeed at whatever he chose to do in life. This included giving suggestions of what might be best for future career requirements, to saying he could do whatever made him happy, to making sure he put effort in to study. Arun appeared to be a very driven student and took his parents' thoughts very seriously, which influenced his decisions going into Year 12.

Others stated specific influences over their decisions, like Lily who described her parents' desire for her to aim high and the pressure that came with that, stating "I feel parents did have an influence. Like, pressure. Not that they [..] purposely put it on, but [..] you feel pressure to choose [..] harder subjects or [..] aim higher." Keira had recently emigrated from Africa to join her mother who was already employed as a community and personal service worker. Her father was still in Africa working as a STEM professional. She discussed how advice from her parents likely changed her career aspirations and educational pathway:

> *I once wanted to be an engineer but then he told me that engineering is hard … Mum told that engineering is mostly a male-dominated course … And then she said [..] it's a good course for me to do, but then she said I'm afraid that probably I will not get a good job … I didn't like the idea but then I came to realise that she might be saying the truth. Cos even when my dad, he took me to [a university level engineering class] to see, the majority of the people in the class are males. There are only five females in the class.*

Keira's parents warned her away from an engineering career due to the male-domination of the occupation and this discouraged her from continuing with this educational pathway. The relationships between gender and STEM are explored further in Section 5.7.2.

5.5.2. Teacher influence

Leading up to subject selection meetings for Year 12 students often discuss options with their classroom teachers. This can lead students to either having the confidence to continue pursuing those subjects or dropping them completely. Eliza was undertaking Biology, Chemistry and Mathematical Methods in Year 11, but discontinued them going into Year 12, stating:

> *The reason why I'm not doing Chemistry or Biology is because I got told by the science teacher this year that it's probably best if I don't … because I just passed Chemistry this year. Because I wasn't really understanding it that much.*

This was a direct effect of the classroom teacher warning Eliza against pursuing a STEM subject in Year 12 due to the anticipated grades she would likely receive. Similarly, Claudia discussed how a discussion with her mathematics teachers resulted in her enrolling in an intermediate subject rather than the more advanced one, stating "I talked to both my [..] Specialist and Methods teachers about it last year and they just [..] recommended that I go to either General or Methods. Because that's where my skill level was at", even though she achieved 'B' grades for all her STEM subjects in Year 11. Other effects can be of an indirect nature but with comparable results. Lily talked about the experience she had in her Biology class with the teacher often describing the difficulty of the subject going from Year 11 to Year 12 and that it would be unlikely that students could improve on their current grade in the Year 12 topic. She explained:

> *I think that's partly from like, my Biology teacher [..] she's constantly saying it's all harder in Year 12 [..] she said the grades that you get now won't change or be better so I thought, oh well, if they're not going to get any better than a B, I probably don't want to do it … just like when we'd get a grade back, she'd be like, "I'm very worried about this group doing Year 12", like a lot of people, including myself, like a lot more other people, decided not to for that reason [..] I don't know if she was trying to motivate us in a weird way [..] but I found it demotivating and like, a knock on the confidence.*

Lily and other members of her class felt as though the teacher was trying to dissuade them from undertaking Biology in Year 12. Her confidence was clearly shaken, resulting in Lily not undertaking any STEM subjects in Year 12.

Teachers of subjects with historically low student enrolment numbers often try and encourage students to continue enrolling in their preferred subject, which would allow the teacher's topic to run. Alana described this situation in a regional school:

> *Usually it's people telling me not to [..] follow the STEM pathway. And that can be other teachers that don't teach STEM … but some of the influences to help me keep doing STEM subjects are, I suppose it's STEM teachers versus non-STEM teachers. [laughter] … my maths [..] and science teachers have recognised that I enjoy doing [..] STEM subjects and they've said "oh, you'd be good at doing this, you should keep doing this" and I've gone, "yeah, that's, that's what I enjoy and that's what I want to do" … there's definitely teachers that I've had that have tried to influence my decision of what I should be doing … I have had influences from teachers which have been positive … I was tossing up between doing Chemistry and Biology as a Year 11 subject and so I went and asked one of my teachers which one I should do and she said Chemistry. But what I haven't told you yet is the person I asked was the Chemistry teacher.*

The influence of a teacher on a student's decision-making process going into Year 12 cannot be understated. Teachers who are trying to increase numbers in their subject are more likely to encourage students to enrol, and those who have larger numbers of students to choose from discourage students who are not likely achieve at a high level, improving the grade aggregate of their subject. They may also make presumptions about future success of students, based on past achievement.

5.5.3. Peer influence

The degree to which peers influence a student's decision of whether or not to enrol in a STEM subject in Year 12 varies quite substantially. Some students were quite adamant that their peers had little to no influence over their subject choice decisions. Zac stated "Not at all. No. It's good to be with your mates but at the end of the day, it's your future, not theirs. So you've gotta do what's right for you." He clearly separated his friendship with peers and their educational pathways from his own journey and educational needs. Tahlia also described this separation within her peer group, remarking "It's not the sort of group who goes "I'll go in this subject if you are" [laughter]. We're not like that." Others described how their peers tried to influence them in their decision-making process, like Alana who commented "There's some friends which have tried to tell me to do stuff or not do stuff … Some of the ones from friends are pretty negative". She went on to illustrate how her friendship group had broadened to include those like-minded students in her STEM classes, suggesting "I've made friends with people in my STEM classes. [Laughter] [..] especially my Chemistry class, because there's only eight of us. Um, we're a very tight-knit group." Although her close friends were not doing STEM and often had negative statements to make about her doing STEM, she had continued pursuing the path she was passionate about and had become good friends with other members of the STEM classes she was in.

One participant described the direct result of a friend enrolling in a STEM subject and the flow on effect that has resulted. Jessica stated explicitly how, if it weren't for a friend of hers encouraging her to enrol in STEM subjects and enrolling in them herself, she wouldn't be doing them in Year 12:

> *And it was also because of my friend who is in Spec and Methods and Chem. Like, she was saying, "oh you know, I'm doing spec, like I think you could do it too [..] you have the same level of understanding" [..] she was actually the one who like told me and encouraged to like, do the chemical and pharmaceutical engineering. Cos like, I'd known about it but I was like, "oh, I'm probably not good enough for that". And then she was like, "no, you've got this". [..] cos in the last Chem test I got the highest mark in the class. And she was like, "you see, you know this, you know what you're doing, I don't know why you wouldn't want to do it". So I was like, "OK, I'll give it a shot".*

The result of Jessica's friend enrolling in STEM subjects and encouraging her to enrol, whilst boosting her confidence in the subjects, had directly resulted in her continuing to pursue STEM subjects in Year 12.

5.5.4. Perceived norm: a summary

In summary, students' perception of norm as it relates to whether to enrol in a STEM subject in Year 12 is influenced by their interactions with parent(s)/caregiver(s), teachers and peers. Students typically discussed their Year 12 subject choice intentions before participating in a subject selection meeting. These discussions were varied. Some parents had little to no influence, some provided conflicting advice on different occasions, and some were very strong in their opinions, which in one case likely altered a student's (Keira) career aspirations. Some of the experiences that students had with their STEM teachers influenced their self-efficacy, perception of difficulty (of the subsequent level subject) and ultimately resulted in them not enrolling in those particular STEM subjects in Year 12. Most of the participants in this research stated that peers did not have a large influence over their decision-making process, even though they had friends who would make negative comments about the idea of them enrolling in a STEM subject. However, one participant described how having a female friend undertake a male-dominated STEM subject with her and provide encouragement and emotional support directly resulted in her continuing with those subjects in Year 12.

5.6. Perceived behavioural control

In the TPB, perceived behavioural control is related to the likelihood of an individual behaving the way they originally intended. The level of *actual* control that a student has over their decision can depend on the barriers and constraints placed on them, often by the school they are enrolled in, as is explored in Section 5.7.5. However, an individual's perception of control over the decision can also give a good indication of the likelihood of success of an intention leading to an enacted behaviour (Fishbein & Ajzen, 2010). In this research, responses to the following question were partly used to assess participant's perceived behavioural control: "Do you feel that the decision to enrol/not enrol in a STEM subject(s) was entirely your decision?" Many replied with a simple yes, followed by a qualifying statement of varying length and complexity. Hayden stated "Yeah. I chose mine, no-one really made me do anything." Alana acknowledged potential influences throughout her life but still felt in control of her subject choice decisions:

> *Overall yes, I feel like it was entirely my decision because even though, if there was influences early on, I was the one who made the final call and I didn't feel pressured into doing it [..] It was definitely my decision.*

Similarly, Brodie made reference to outside influences whilst maintaining control over his decision:

> *It was my decision. There were subjects I chose but whether or not that decision has been influenced by the way I've been brought up and the way that schools are now [..] sub-consciously with all of the [..] positive stuff surrounding STEM, and it's [..] prevalence at home, probably has influenced that decision to a degree. But [..] I can't really [..] picture a situation where I probably wouldn't have chosen those subjects.*

Brodie noted how his father being a STEM professional and the STEM related experiences he had with his father's associates may have influenced his interest in STEM on a subconscious level. The current promotion of STEM learning in schools, in his particularly, had also potentially changed his view of STEM education. Keira added a further comment to the relationship she had with her father and his thoughts about the direction she should take in her education:

> *Half of it was my decision and then the other was my dad's. Because he thought that finally if I did STEM subjects it's going to be easier for me transitioning from [Africa] to here and I thought it will also be good if I did STEM subjects because science never changes.*

Many participants acknowledged the direct or indirect effects that external factors had on their decision-making process. However, all participants felt the decision of what subjects to enrol in for Year 12 was ultimately their decision unless they did not have *actual* control as described in Section 5.3.

5.7. Background factors

The diverse range of demographic backgrounds of students in this research was likely to influence the way they viewed the world due to differing life experiences they had. The TPB outlines how background factors related to individuals are likely to indirectly influence their set of attitudinal, normative and control beliefs, thus influencing their intention and subsequent enrolment or non-enrolment in STEM subjects in Year 12 (Fishbein & Ajzen, 2010). A student's *career aspirations* and the level and type of *education* required to achieve those aspirations are often stated as key factors in their Year 12 subject choice decisions (see Section 5.7.1.). The gender gap in certain male-dominated areas of STEM was explored through female participant's excerpts relating to the concept of *gender identity* and how those identities were formed within the classroom and at home (see Section 5.7.2.). Some participants shared their desire to understand how interactions within society operate and how the brain 'works', resulting in unique aspects related to *altruism, wonder and personal past experiences* being attributed to particular participants (see Section 5.7.3.). This idea was explored further when participants had aspirations to pursue STEM to a high level due to their desire to help people. The *educational level and occupation of parent(s)/caregiver(s)* were shown to influence the career aspirations and enrolment plans of students within this sample (see Section 5.7.4.). The *school context* that students were placed within, particularly those from a small regional school, could lead to a loss of *actual* control over the decision of what to study in Year 12 (see Section 5.7.5.). Students' *prior achievement in STEM* subjects ultimately influenced their attitudes towards the subjects and their willingness to continue pursuing them to a higher level, even if they could see the benefit of studying them further (see Section 5.7.6.). The perceived *quality of previous teachers* in STEM affected students' attitudinal and normative beliefs related to that subject area, even if those particular teachers may not be teaching the subject in Year 12 (see Section 5.7.7.). The opportunity to gain *STEM exposure outside of the classroom* often increased students' attitude towards STEM subjects, raising curiosity levels and enjoyment in the field (see Section 5.7.8.). The constructs mentioned here are explored further in the following sections.

5.7.1. Education and career aspirations

A student's career aspirations and the educational pathways that likely lead to that career are found to exert a significant influence on the decision-making process as they enter into Year 12. As with enjoyment of STEM subjects, career aspirations and educational requirements associated with those careers are often cited as important factors in response to the broad opening question "How did you come to the decision to choose your subjects for Year 12?" Many of the responses were short but clear, like Claudia who stated "I based it off what I wanted to do when I leave school." A common goal for students entering Year 12 is to set themselves up for life post school, including employment and further education. Educational requirements such as subject pre-requisites for university degrees and strategic subject selection due to scaling practices in particular subjects for ATAR requirements are often key factors in many students' subject selection decisions. Tahlia explained how she had chosen Mathematical Methods as she was enjoying it in Year 11, but chose Biology "because I needed that for uni as a prerequisite." In a similar way, Hayden cited potential pre-requisites as a reason for choosing Physics and Biology, even though he didn't have a clearly defined career path in mind:

> *I [..] wasn't that sure on what I was going to do once I finished school, so I just decided I'd do what I enjoyed and ones [..] that I could do different things once I finished Year 12 [..] so there were heaps of options I could have.*

The concept of keeping options option are generally related to completing those subjects that are typically listed as pre-requisites for university courses, often STEM subjects. A student who is unsure of what they wish to pursue post school but is likely to follow a university pathway would typically be recommended to enrol in STEM subjects, qualifying them to apply for the full range of courses. Participants also stated they did not choose particular STEM subjects because they were not perceived to be useful for their intended educational and career pathways. Scarlett explained:

> *It's subjects I enjoy and subjects I know that will help me in my career path that I want to do at the moment. If I wanted to do something that involved maths, then I would do maths, even if I know I don't enjoy it very much. But at the moment, doing digital media and design, I've been recommended by the [..] coordinators [..] to do that … if I wasn't doing the Art thing, I probably would enrol [..] in a math [..] and maybe Biology. So that, they are something that I would kind of want to do, but [..] they're not going to help me get towards the uni course I want, so I won't be doing them.*

Scarlett highlighted her willingness and desire to enrol in more STEM subjects but had decided not to enrol in them as they were not necessary for her career and education pathway. Arun was quite clear about his decision making and the reasons for making those decisions:

> *I thought about a subject that will help me like, reach my path [..] So I basically did a plan [..] what subjects will help me get a good ATAR, first of all [..] And what ah, subjects are required for me in order for me to get a degree. So for Business [..] I needed ah, general English and I needed good level of maths. So I chose General Maths, English, and Business Enterprise which was related to my course.*

Arun went further rationalising why he didn't enrol in STEM subjects in a similar way to Scarlett even though he was confident that he could do well in them:

> *Specialist Maths has something to do with engineering and I have no interest in that. So basically, cos it wasn't teaching any stats, any financial stuff [..] rather than doing irrelevant stuff that has nothing to do with business, I chose to do General Maths, cos they will be covering financial stats and indices and other stuff which is really important for my degree. That's why I've decided to step down.*

Arun also discussed the strategic nature of the decision-making process by choosing subjects that were likely to be scaled down or not scaled at all but which he would likely achieve at a high level, as opposed to enrolling in a subject that may be scaled up, but he would not achieve at a high level:

> *I think I will be doing good in these subjects and I think if I get A's throughout the year, I'd have a pretty strong ATAR [..] if a person with Specialist Maths is getting a C-Minus, and I'm getting an A, I think I'll be getting scaled up. I think, that was another reason as well [..] depending on the grades, what grades I'll be getting, if I'm doing Spec Maths, I will be getting a B. And I didn't want that. Well, I might be getting a B here and oh, I might get an A in General as well, that was another reason I chose general.*

Some students have educational aspirations for university degrees that have particular STEM subjects listed as pre-requisites. For those who do not, the perceived utility value of STEM subjects is decreased with the emphasis being placed on ATAR scaling tendencies. Whether this strategy ends up helping them in ATAR calculations or not, many students' perceptions are that their strategic decisions will likely to pay off with their ATAR being improved.

5.7.2. Gender and STEM

Gender differences were apparent in some female participants' responses, acting as a potential barrier in their STEM subject choice decisions for Year 12. The first was Keira, who as discussed in Section 5.5.1. had once wanted to be an engineer but her parents told her that it would be hard. This was likely due to the male-domination in the field of engineering. Keira's father took her to an engineering lecture at a university and she could see for herself the gender imbalance of the class. Her father went on to suggest what he perceived to be more 'suitable' careers for her:

> *He recommended me to do medicine … He thought that will be too hard for me to do engineering specifically. I wanted to do it in college and he told me that "it's a hard subject [..] but I might think of being a teacher or possibly doing something to do with children, that's a good job option".*

Keira had decided to pursue medical related careers such as dentistry or optometry as potential education and career path options. Keira's experiences with her parents had altered her education and career trajectory due to gender stereotypes being reinforced at home.

Jessica also discussed in great detail how the gender makeup of a STEM classroom had impacted the STEM decision-making process going in to Year 12. She talked about the role of her friend (also female) in both helping her to develop her self-confidence in STEM and through simply having another female in the class for emotional support. Jessica first highlighted her friend's influence and her general attitude towards STEM:

> *She [female friend] was the one who like, told me that I really should be in [Specialist Mathematics]. And if she hadn't been in the classes, like if she wasn't in specialist, then I probably would not have considered it at all. Because it's a very male-dominated class. Like we have I think its eight students and only two of us are girls. So if I was the only girl trying to go in, I would have been like "oh, nah, like, I'm alright, I'll be fine with what I've got". And that's what I thought STEM is. Like, it can be very male-dominated in certain subjects. Because I feel like, um, either girls aren't interested in it or they just aren't given the same sort of opportunities as the guys are.*

This furthers the idea of certain areas of STEM being male-dominated and the adverse effects it may have on some females' educational enrolment decisions. Jessica then started to elaborate further on the role of her female friend who increased her self-confidence in STEM and the importance of having another female student in the class:

> *There's a high chance I wouldn't be doing it because I would feel like I wasn't like, good enough … If I didn't have [female friend] telling me like, I can do it and "you'll be fine", and all that, "I'm doing it too, it's all good", then I'd be like, "oh, I don't want to do it"… I feel like it makes it feel more welcoming because I'm not like, singled out [..] I know that if I walked into a class with all guys, it'd be like "oh god", they'd all look at me like, "great" [..] I think having at least another girl in like, a male-dominated class [..] you sort of make a connection with them and like that connection grows. And then like, you bounce ideas off each other and you just like, motivate each other [..] so if she gets [..] a really good mark on her test, like I'm really happy for her, like I'll motivate her, like "that's really good", and if I don't get as good of a grade, like she doesn't like put me down, she builds me up. And I feel like having another girl just sort of helps with that. Just sort of makes me not feel like oh, "OK, maybe I can't do this" [..] because for the rest of the guys, I'm a girl, maybe I'm not good enough [..] just having another girl just sort of makes it [..] a better environment, cos I feel like I'm not the only one in there.*

Jessica clearly valued the relationship she had with her female friend and stated quite clearly how not being the only female in a male-dominated class had a significant impact. Jessica moved to discussing her role within her family with three older brothers and being the only female besides her mother. She related the idea of her mother having an emotional connection with her in a similar way to her female friend in Specialist Mathematics:

> *I feel like having like, my mum there, we were able to connect on like, more of an emotional thing. Because um, not all guys but most guys, tend to hide their emotions, not really talk about it [..] I feel like in spec, it's nice to have like, another person there who you can just talk about that sort of stuff with although I'm not having a good day and she'd be like, "that's not OK, are you alright, what's going on?" But I feel like if you said it to a guy, he'd be like, "that's sucks. Like, OK".*

From these excerpts it appears that the barriers to her continued participation in STEM subjects were related to the idea that they were male-dominated and her male peers lacked the emotional capacity to encourage her and allow her to vent and discuss how she was feeling if things didn't go well in class, which she seemed to value greatly. The role of the female friend addressed these issues as the emotional support, self-confidence builder and simply another female to take the spotlight off her in a male-dominated area.

5.7.3. Altruism, wonder and past experiences

A trend that was identified throughout the interviews is the connection between students' desire to learn about the brain and how people operate (wonder) and a desire to help people (altruism), perhaps due to their past experiences, and enrolling in subjects that help them achieve those goals. Scarlett enrolled in Psychology for Year 12 and described how her fascination with people led her to want to know more:

> *I really like learning how people work and how the brain functions and how people's motives [sic], it's really interesting and scary when you start learning about how people all function … Personal, wanting to learn more about yourself, really, I guess. And connecting with who you are as a person and as a species and society and how people work.*

Enrolling in Psychology was Scarlett's way to better understand herself, other people and the world around her which she placed an emphasis on in her subject decision-making process. Many participants described how their desire to help people influenced the subjects they were going to enrol in for Year 12 as well as their post school education pathway and career aspirations. Zac discussed his desire to pursue cooking in the military, stating “military’s always interested me and [..] it’s always good to give back to the people that [..] risked their lives [..] to protect us. And as a chef [..] you’d be helping them as best as I could.” Suchitra was boarding at an all-girls school, coming originally from Asia. She highlighted her desire to help other people due to her experience in her home country:

> *I feel like, if I have one life, and I just want to make the best of it. And I just want to [..] use what I have [..] to help other people … I think you start being, like in [Asia], seeing like the less fortunate people and [..] experiencing that part, it’s kind of make me want to help other people … there are so many problems going on right now [..] how do we prevent that from happening, we can control it, we can like, make the world like better and like, keep it going for the next generations.*

Suchitra’s experience growing up in Asia had shaped her worldview to the point where she felt compelled to help people and change the landscape of society for the benefit of future generations. Like Suchitra, Emily had developed a passion for Psychology through her own personal experience with a clinical psychologist:

> *I guess the helping people part of it. Like, the fact that [...] you can help them out. Cos I’ve been helped out quite a lot, and [..] you see on the news about all the people that are [..] messed up and you feel like you could [..] do something to help that.*

Emily described how a positive experience in psychology consultations had made her so much more aware of issues within society that she now felt compelled to help other people. Similarly, Jessica outlined in detail her experience with her father and how a road vehicle accident and the recovery that ensued had changed her vision of what to pursue in life:

> *I knew the reason why I wanted to help in the [..] medical side was because of my dad [..] he has like, health issues. Because he was involved in like, a truck accident and [..] has some chronic back issues [..] that he’s never going to get rid of [..] so I think that’s why I sort of steered towards like, the medical side [..] I want to be able to help someone like that, even if it’s not my dad, at least it’ll be somebody who I can like, improve their life.*

A student’s personal experience and personality traits that develop as a result of them, can ultimately influence their passion for a subject and subsequent career trajectory.

5.7.4. Parent(s)/caregiver(s) educational level and occupation

A parent(s)/caregiver(s) level of educational attainment and area of occupation was shown to have an effect on students' level of interest in those areas and subsequent enrolment in higher levels of education. This was shown to be the case for both STEM and non-STEM related areas for participants in this research. Arun described a passion for business, which he partly attributed to the experience he had with his father:

> *He spends time with the family at the same time as working for his business. That's what [..] intrigued me the most, about learning how to set up my own business. Because my family background like, if I go to [Asia], my family has a lot of businesses there as well. And when I was a kid, I was usually raised up in that environment, which I found really attractive.*

Arun viewed the work that his father did in order to be to be successful in a business environment, including the long working hours and time missed at home, with pride and admiration. He went on to describe how the sacrifices his parents had made for him to get a good education influenced his attitude towards schooling and life more generally:

> *Cos the hardships they went through, to get us to this stage where we are right now and where I'm educating. I give them all the credit they deserve cos [..] my family background was pretty good, but we had some family problems as well which made us come here. And I know the struggling, cos like working ten hours a day, twelve hours a day, and managing a company as well. [..] I want to do something for my parents. [..] we're not living with our families' relatives, so they've sacrificed a lot. And I don't want their sacrifice to be a waste. That's why [..] I'm sacrificing my childhood, basically, I could be spending it going to parties and stuff but that's not my personality.*

Arun followed this discussion by describing how his parent's level of education and previous experience in Asia had changed the way he views the world:

> *I've just seen that [..] my parents [..] they're really educated as well [..] my mum was a [educator] in [Asia], and my dad has been a [media employee] for over 25 years. So he's got plenty of experience. So they've taught me the value of education and how education can change the world.*

In a non-STEM context, the influence of Arun's parent's level of education and occupation had helped shape the way he envisaged the value he could bring to the world and the resultant education pathway and career aspirations.

Students who have a parent/caregiver with either an interest in STEM or who work in a STEM related field are more likely to have an interest in or passion for STEM, resulting in wanting to study STEM in Year 12 and, in some cases, forming a career aspiration for a STEM related field. Alana described how her parent's education and career trajectory influenced her curiosity for science:

> *My mum was into computer programming and she went to university to study that, so she was into a lot of technology and how things worked and [..] my dad as well, he does a lot of environmental science type stuff, so more of the biology kind of side of things. So [..] my parents had a lot of scientific influence on me, and [..] that sparked that curiosity.*

Samuel discussed his father's role in the community as a STEM professional and how that had helped him to consider a medical pathway:

> *He was a [STEM professional] for quite some time [..] and personally I don't think that would really be something that I could see myself doing, but now that he's not a specialist, but he's specialising in [a different area] and that's quite[..] interesting cos he's actually doing a lot of good for people. He's actually [..] doing a lot of good in the community and [..] he said that it's really rewarding.*

Although Samuel did not necessarily have his heart set on the same field as his father, his father clearly influenced the way Samuel thought about the field due to the benefit his father was to his regional community. Brodie also described how his father's career and the work that his father brought home with him had helped to shape his desire to pursue an education and career in a related field:

> *My dad brings a lot of his work home so, you know, he'll come and talk to me and my brother about it and he'll have us sit around and watch what he sort of does and [..] because I've expressed an interest in doing [STEM professional career] [..] he'll sort of show [..] the sort of work that he does at home … I've always been brought up in this sort of environment where STEM is really the only really rewarding career, so that's definitely what's led me to choose it.*

The experience that Brodie had at home through his father's work had strengthened the relationship he had with STEM and the benefit of pursuing a STEM related career. Edward also wanted to follow in the footsteps of his father who worked as a STEM professional, with the desire to be become an electronic or mechanical engineer:

> *Mainly because I've got a big interest in rocketry. And my dad's a [STEM professional] so, I'm pretty sure I could [..], choose a career pathway that way as well. And also, there's a lot of electronic systems in rocketry. That's kind of what I'm interested in at the moment.*

Edward's passion for STEM shone through in his interview detailing how he designed and built model planes at home and discussed aspects of STEM with his father and his colleagues at great length. The relationship between a student's career aspirations, subsequent choice of STEM subjects in Year 12, and their parent(s)/caregiver(s) level of education and occupation is clear.

5.7.5. School context

The context of the school that a student is attending shapes their experience and perception of education. However, in unique circumstances like the small regional school that four of the participants were attending provided specific barriers that precluded them from enrolling in STEM subjects in Year 12. Barriers that are described throughout their transcripts relate to multiple subjects they wished to enrol in being offered at the same time due to the timetable structure, subjects not being run, or year levels being combined due to low enrolment numbers or staffing problems and the flow on impact that had on their learning. Hayden described how he would have preferred to enrol in mathematics but it clashed with another subject that he deemed more important for his future:

> *I probably would have continued with one of the maths, it just didn't fit in with anything else I was doing [..] didn't fit on the same lines. So I couldn't do it. Or if I did, it would be challenging cos it would be during another time so I'd have to do it on my own time.*

Students in regional schools often face difficult subject selection decisions due to these constraints of whether to study a subject through the Open Access College (OAC) with a combination of online and virtual classroom lessons (Open Access College, 2018), which often requires them to study in their own time without the guidance of a teacher in a face-to-face format. There may be some opportunities for a teacher within the school to help students in their own time or for students to attend workshops run by the OAC but these require travel by students in regional schools. Sometimes, schools simply cannot run a subject due to low enrolment numbers, resulting in students not being able to study their preferred courses as Eliza outlined: "I was going to do Scientific Studies next year but [..] they couldn't run it [..] so, I'm doing Home Ec instead." STEM subjects aren't the only ones to suffer from these constraints.

Tahlia discussed how her desire to study history in Year 12 was not fulfilled as the subject was not able to run due to the usual teacher going on maternity leave, without being replaced:

> *I intended to do history but [..], they weren't running the history course cos our teacher, the history teacher now is pregnant so she won't be here next year … I think there were at least um, five of us that we know of in our class who wanted to do history and we thought that would have been enough for them to get a history teacher … they gave us the option of doing it Open Access or um, seeing if they could try and find like a [neighbouring] school that we could go to um, to do it. But none of us really wanted to do Open Access in Year 12 or travel that much.*

The issue facing small regional schools is the supply of suitably qualified teachers to be able to offer and run the full suite of subjects that students in their school wish to pursue. Tahlia described how several students wanted to enrol in history in Year 12 but the notion of having to study the subject in an open access mode, or having to travel to a nearby school, was simply too much to handle. The other issue of having low enrolment numbers in some STEM subjects is that classes need to be combined. This is due to the school only being able to supply a teacher if the minimum requirement for student numbers in the class is satisfied. Vertical classes where a Year 11 and Year 12 cohort are sometimes combined for a subject to satisfy these requirements, results in a unique set of complexities as Tahlia discussed:

> *It was very annoying [laughter]. I found it very hard because yeah, especially in Biology and Chemistry, cos our course was based on [Year 12 course]. And so it was a bit all over the place … whatever they were doing, the teacher would try and match our course with theirs ... So we'd be like, at the start of the chapter and then they would change to a different topic and so we'd go to the end of the chapter … we've found it really hard. And we're just [..] fixing the holes in our course.*

The responsibility of the teacher to teach two different courses in the same classroom with no extra time makes it difficult to teach, and more difficult for students to learn. Issues outlined in this section are commonplace in small regional schools.

5.7.6. Prior achievement in STEM

A student's prior achievement in STEM subjects is likely to alter their attitudes towards those subjects and subsequent enrolment in them for Year 12. This can result in an encouraging or discouraging effect on their enrolment plans.

Brodie described how his previous results in STEM subjects had led him to be confident that he could continue achieving at a high level in those subjects at the Year 12 level:

> *Getting all A's and going into it next year [..] I think it means that I'm not sort of put off by the fact that it's going to be a lot of hard work and that it's going to be very difficult. I think the fact I'm demonstrating good grades [..] sort of means to me that I think I reckon I can handle it next year as well.*

Alana also outlined how prior performance could predict future performance leading to her continuing to enrol in STEM subjects in Year 12, stating "Doing well in Year 11 [..] means you could potentially do well in Year 12 because you are good at that subject at the Year 11 level and you can improve on it at the Year 12 level." The confidence that students can gain from prior performance can alter their perception of achievement at the higher level. The contrasting effect can also influence students' decision-making processes, like Lily who decided not to enrol in any STEM subjects in Year 12:

> *So maths, I did Methods in Year 10. It was like, really up and down [..] some tests I could get ninety percent and other ones I'd like, just pass [..] it was like, up and down and not something I wanted to do in Year 11 and 12.*

Inconsistencies in Lily's results at the lower level of mathematics reduced her confidence in the ability to achieve at a satisfactory level in the higher grades. Eliza also discontinued studying STEM subjects, describing how she would likely have enrolled in them if she was achieving at higher level, explaining "If I'd been doing well in Chemistry and Biology, I probably would've ended up doing them next year." From these excerpts it is clear that a student's prior achievement in STEM subjects affects their attitude towards those subjects, including confidence to keep pursuing them, and subsequent enrolment in them for Year 12.

5.7.7. Teacher quality

The perception a student has of the quality of teachers within subjects they are undertaking or planning to undertake affects the way they view the subjects and whether they plan to continue enrolling in them. Many of the participants described how high-quality teachers enhanced their enjoyment of the subject, increasing the likelihood that they would enrol in the subject in Year 12, particularly if those teachers were going to be their teacher at that level.

Alana discussed the biggest influences over her decision to enrol in Nutrition and Biology:

> *Our school has good teachers for those two subjects, which definitely helped because [..] good teachers can help you do the subject well … they explain things well, they actually give you reasonable time periods for doing assessment tasks, because sometimes you get it where you're expected to do something [..] in an unreasonable amount of time and then that makes it really difficult to do.*

Alana then proceeded to describe how her mathematics teacher's teaching method had changed her perception of the subject even though the subject was difficult:

> *She was a good maths teacher because she [..] knew what she was talking about. She had other methods of teaching besides [..] textbook kind of teaching and she had methods of, if it didn't make sense to us, there was other ways that we could look at it and [..] learn about it. So it made doing maths, even though it was a difficult maths subject, [..] pretty easy. So I enjoyed having her as a teacher.*

Alana made the link between teaching pedagogy, understanding concepts and enjoyment of the subject quite clearly. She summarised her experience, stating "if you don't have a very good teacher that can affect your enjoyment of the subject."

Other participants discussed how negative experiences with STEM subject teachers had altered their perception and enjoyment of the topic. Anna chose her subjects in Year 12 within a unique context. She was on an exchange from Western Europe, one in which the subjects she chose could not be counted towards her high school certificate back home. This gave her a sense of freedom to choose humanities subjects that she described as 'interesting' to her and allowed her to better learn the English language. As she was on a mathematics and science track in Western Europe and she was not concerned with obtaining a high ATAR she chose subjects for the experience of doing something different. Anna's previous experience with mathematics was not ideal:

> *Really bad, yeah. Before I started high school [..] the middle school in [Western Europe] [..] is nine years. And then high school is four years. So the teachers I had during those nine years [..] were quite bad … Ah, they were bad at explaining. They just assumed that if they explain something in one way, everyone will get it, just because they did.*

Luke also outlined his negative experience with previous mathematics teachers:

> *Maths, not so good. I've never really had a good maths teacher … I feel like they should have given me more encouragement I guess, cos in maths if I don't get it I just stop, I just shut down. And they don't continue, they just leave me be.*

The perception of teachers in mathematics moving too quickly through content, leaving students who have not fully grasped the concepts being taught, is an all too familiar story. Scarlett confirmed this type of experience in science:

> *For Chemistry, she was just really, really strict. And I didn't really like the way that she ran some of the things but obviously because it's such a hard subject and cos the pace is pretty fast of what you need to learn, [..] I didn't connect with her as a student.*

A teacher's pedagogical approach can also have a negative effect in science classes as Eliza outlined:

> *It might have made it a bit more interesting, just having different ways of looking at it. Because, in Year 11 and 12 we really only have the two science teachers and so [..] the way they teach is the only way you can see things. So you don't really get a range of views and different learning styles and techniques. Cos, I think the reason why I didn't really do so well is because the teacher's teaching techniques doesn't really line up with how I learn … she pretty much just gets us to watch YouTube videos, and going through some other PowerPoints but we don't really take many notes and it's mostly out of the textbook. So, [..] you learn what you need to, but you don't really get a deeper understanding of it.*

Eliza's level of understanding was affected by the teaching style and pedagogical methods employed by her science teacher. She described specific methods and classroom activities that she found to be ineffective. Eliza then discussed how a pre-service teacher, with a different way of teaching, had altered her perception of Chemistry:

> *She really did help with her different teaching techniques and her different point of view of how to teach … it was pretty much she just had a different, oh, point of view and therefore she had a very different way of interacting with us, different ideas, new ideas and improvements … she had her own notes and different variations of the notes that we had to take and different ways of understanding it and she, though, I know this isn't really an important thing but she was a bit younger than [usual teacher] and she was going through teachers' college [..] and she's a lot closer to our age. And she understands a bit more about how we learn.*

The perception that Eliza had about the age of the teacher perhaps being able to more effectively communicate with students and employ more interactive learning strategies is evident. Arun discussed at length his relationship with teachers and how that affected his understanding of a topic.

He too described how teaching methods negatively affected his experience:

> *They gave me clear instructions but sometimes they have to be more clear and they just sit down with a student. Cos everyone works in a different way. So that, instead of just having one method of teaching, they should have different. I know, one formula has one method of doing it, that's perfectly fine. But you need to sit with the student after you giving him work as well, not just working with students who are really smart. Cos there were some students in my class, I'm not going to name any of them, but they were struggling. They were like "how do I do this?" and the teacher was like, "I'll show you" but spent like a minute. I know that there's 10 kids, 10 or 20 kids, but trust me, normally in Asian countries we have 50 kids. It's not, it's not even a big deal. People, teachers can see it as a big deal, like managing 20 kids. Like, it's not. So people were struggling. Teachers should give them their time, cos they're getting paid for what they're doing. They're not doing us a favour. That's what I think. Cos that's what I'm about, like you're getting paid, you have no right to say "oh, oh, there's too much to do" then just quit the job. There's too many people, there are a lot of teachers waiting outside to get your job.*

Clearly, Arun had a unique perspective of the role of a teacher and how a classroom should operate. His experience of being in a classroom in Asia with large student numbers had altered his perception of what he expected from teachers. Further, he discussed how a teacher would not help him with his work as they viewed him as a competent student that did not require the level of help that other 'less competent' students in the class may have needed:

> *I've had negative experiences with teachers as well. Because the lack of effort they put in, especially for work, they're like "yeah I'll come, I'll come back, I'll help you out in a second", then it will take 15 minutes, talking to one student, talking to another student. I just don't like teachers who get easily distracted. And like, when a student really needs help, then why not give them that help. Like, you can do it, you just need to try your best. What if he's tried their best, because you never know. You can't read their minds. So I just don't like teachers who have basically characterised a kid as "oh, he's capable of doing this". Cos that's happened to me, that the teacher's like "you can do it, I have faith in you". And I'm like "teacher, I've been trying this for two days. I don't get it. So what makes you think if I do it now it'll work. I'll give it a minute, doesn't work, you have to help me out". She'd be like "oh, let's see how it goes". Then completely, my whole day is ruined. Sometimes I spent 25 minutes in Year [11] doing nothing. Cos I've been waiting for the teacher.*

Arun's clear contempt for the teacher of the class he described had negatively affected his experience within that class. This excerpt emphasises the vital importance of the teacher-student relationship on student success, enjoyment and future enrolment in a subject.

Some participants outlined how their attitudes towards a subject had changed over time depending on the teacher they had in a particular year level.

Jessica discussed how previous experiences with a mathematics teacher may have led her to study Essential Mathematics, but more positive experiences later on had led her to undertake Mathematical Methods and Specialist Mathematics in Year 12:

> *The teachers [..] I think it was Year 9 [..] they just weren't as into it as the, as my two teachers now are. And I think that's just because of Year 9's like, not that important. And like, I had a maths teacher, he was a decent maths teacher [..] but like he was mainly PE, so he [..] didn't really focus in or didn't seem to have that much understanding of the actual topic that we were trying to study. And I feel like that made me like, less motivated to do it, because I wasn't understanding it. So it was like "oh, I can't do this, I'm not good enough to be able to do this" [..] then I was like "you know what, I'm just going to try and like, if I don't get it, I'll just drop down into [Essential Mathematics]". And then I had a really good teacher in Year 10 who was [..] really like pushing, like he had a really deep understanding of the topic. If you had a question he could explain it and then make sure you understood it. Where in Year 9, they were just sort of like, "this is how you do it, whatever, move on". But I feel like if the teachers [..] straight from Year 8, were really motivated about teaching the subjects, then I feel like more people would be interested in it.*

Jessica outlined the importance of previous experiences as far back as early high school and the effect that can have on a student's attitude towards and future enrolment in mathematics. Brodie also discussed the comparison of a 'good' versus 'bad' teacher in STEM:

> *I've had some teachers who probably weren't as good as others. Ah, definitely my teacher for Physics and maths this year is very good and he's, ah, he's very supportive and he takes [..] less of a direct approach to teaching. Rather than just standing up and teaching [..] it's more involving the entire class with it. Especially now that, in these subjects there are a lot smaller classes, means that there can be a lot more sort of personal contact between the teacher and the student rather than just a teacher talking to a room full of people. And I guess [..] obviously STEM teachers are going to be passionate [..] about what they're doing and they're going to instil that in any of their students.*

Brodie went on to summarise his view of the influence of teachers on his learning in STEM:

> *I've had some poor STEM teachers and I've had some great STEM teachers, but the great STEM teachers have left more of an influence for me to do STEM than the poor STEM teachers have led me to not want to do it.*

Brodie's reflection on the power of a positive experience within STEM clearly articulated the importance of effective teaching and relationships with STEM classrooms.

5.7.8. STEM exposure outside of the classroom

The exposure a student has to STEM outside of a classroom setting can influence the way they view applications of STEM more generally. Responses from participants were quite varied with many having little significant experience with STEM outside of the classroom, while others had unique upbringings where STEM was an integral part of life from an early age. For those who do share their experiences with STEM outside of the classroom, value is placed on learning about applications of STEM and the integrative nature of STEM, the interest that is developed as a result, and gaining knowledge about STEM career options available to them. Alana discussed her experience at a science and engineering challenge:

> *I've had the opportunity to go to two science and engineering challenges that are run by the University of Newcastle [..] and the activities that we do there really involve all four elements of STEM in problem-solving and [..] some real life situations … that have given me an opportunity to connect all the parts of STEM together … they probably helped because it showed [..] practical applications for the subjects.*

Although Alana did not have a desire to pursue a STEM career at this stage she mentioned how these experiences positively influenced her view of STEM and contributed to her continuing to study STEM subjects in Year 12. Suchitra described how a STEM related excursion changed her perception of the field:

> *I went to a STEM trip and it really opened up my eyes, with [..] what we can do with our [..] skills and [..] STEM subjects. And [..] how we can go [..] outside the world and study something that we can come back and use in our world.*

Suchitra valued the experience and the knowledge of how applications of STEM were useful in her personal everyday life. Brodie had career aspirations in the engineering field, which were bolstered by his experience visiting the International Astronautical Congress event, stating:

> *Being able to [..] see what [..] the global sort of companies are doing, what they're creating, getting to talk to the people there was [..] really invigorating for actually wanting, continuing to do STEM because it's a group of like-minded people who [..] all have sort of chosen the same career path and they were all just generally passionate and excited about what the future holds.*

Brodie's experience with role models in the field is an example of how exposure to STEM outside of the classroom increases students' awareness of and positive perception of STEM.

He went further describing how he enjoyed discussing aspects related to engineering with people within the field:

> *One of my dad's friends from Canada [..] is over here for a conference. And so we were having dinner with them and [..] most of the discussion I had last night was about ADFA, it was about engineering, it was about certain aircraft and [..] it is nice to be able to talk to people who are in a similar field.*

Samuel also described how a discussion with family members within the medical and engineering fields had helped to develop his understanding of where a STEM career might lead him:

> *I've got some cousins in Queensland that are doing medicine and engineering. So [..] there are three cousins who are all doing that sort of stuff that I've got interested in, so [..] I've spent some time with them and spoke to them about [..] how they sort of went about doing what they're doing and how their careers are.*

This experience, combined with his father and mother being in STEM managerial/professional roles, had contributed to Samuel wanting to pursue either medicine or engineering.

Alana's exposure to STEM at home, through her younger brother's science experiments, had allowed her to develop a passion for science and a desire to learn more:

> *My brother's in Year 9 but he has [..] an amazing understanding of Year 11 Chemistry and [..] currently he is building a sugar rocket, [..] some crazy science project. But he's always been heaps more interested in STEM subjects than I have and I'm not quite sure what's influenced that but [..] his interest in science has definitely made me want to learn more about it because then I can help him with his crazy projects … My brother and I have a very good relationship and we have a lot of similar interests so [..] when he decides to do experiments, I go "oh yeah, this is really cool", because I'm interested in science and he's interested in science and sometimes [..] he'll pop up a random question, like the other day he asked if [..] sugar was a hydrocarbon and so I went and looked it up [..] I suppose his science has influenced me doing background research so that he doesn't accidently blow stuff up. [Laughter]*

Alana's exposure to STEM outside the classroom and investment in her brother's learning of STEM concepts allowed her to investigate STEM concepts at a deeper level and more often than other students in her class.

5.7.9. Background factors: a summary

In summary, numerous background factors are shown to influence students' attitudes towards STEM and likelihood of enrolment in a STEM subject in Year 12. Prior experiences with STEM both in the classroom (including achievement, teacher quality and pedagogy and curriculum content) and at home ultimately lead to students developing education and career aspirations. The aspirations that are formed throughout schooling lead students to follow pathways either in or out of STEM. Other factors such as a student's level of altruism, wonder and past personal experiences can allow students to develop a desire to pursue STEM beyond the compulsory stages of schooling. Moderating the development of identity and affinity with STEM are cultural and gender stereotypes, as evidenced by Keira's remarks throughout the chapter. The level of actual control that students have over the decision of whether to enrol in a STEM subject in Year 12 is influenced by various contextual school level factors such as school size and the resultant enrolment numbers, timetabling constraints and ability to recruit and retain suitably qualified STEM teachers.

5.8. Summary

The findings from this chapter extend the findings presented in Chapter 4 whilst addressing Research Question 2 "How do background variables influence beliefs about STEM, intention towards STEM and enrolment in STEM subjects in Year 12?". The relationship between a student's intention to enrol in a STEM subject in Year 12 and whether they enrolled in those subjects was explored through the use of excerpts from participants' transcripts in response to the question "Going in to your subject selection meeting, did you select the subjects for Year 12 that you originally intended to?" Following this, many sub themes were identified relating to the overarching theme of attitudes towards STEM, including enjoyment and interest in STEM, self-efficacy and identity and affinity with STEM, the nature and perceived difficulty of STEM subjects, and the personal and societal value students place on STEM. The influence of parent(s)/caregiver(s), classroom teachers and peers was explored in relation to perceived norm, which is a student's perception of what significant people within their social circle think they should enrol in for Year 12. Following this, the perception students had about the level of control they had over their STEM subject choice decisions going into Year 12 was measured by responses to the question "Do you feel that the decision to enrol/not enrol in a STEM subject(s) was entirely your decision?" A variety of background factors were identified that influenced the enrolment decisions students made. These included education requirements due to career aspirations, gender identity, altruism, wonder and past experiences, educational level and occupation of parent(s)/caregiver(s), school context, prior achievement in STEM subjects, perceived teacher quality and exposure to STEM outside of the classroom. As mentioned in the introduction section, many of the findings presented in this chapter are consistent with the results outlined in Chapter 4, including demographic background (gender, SES and immigrant status), attitudes towards STEM (enjoyment, value and self-concept), achievement in STEM and school type and context.

6. DISCUSSION

6.1. Introduction

The discussion provided in this chapter extends the findings of the research presented in Chapters 4 and 5. This extension includes discussion of findings that are either consistent with, in contrast to, or that provide an addition to prior research findings. In doing this, a synthesis of qualitative and quantitative data is made, with both expected and unexpected results outlined in an attempt to understand the STEM subject enrolment decision-making process of students entering Year 12. A short discussion (see Section 6.2.) on the value of the adapted theory of planned behaviour (TPB) as the guiding conceptual framework used in the study is presented. An argument is outlined for employing multilevel analyses when the TPB is used with nested data based on the synthesis of quantitative and qualitative findings. Section 6.3. to Section 6.10. provides a discussion of eight key factors and the interrelationships with other influential factors of interest. This discussion, along with a comparison with prior research and an interpretation of the findings, addresses both Research Question 1 "What factors (student and school) influence students' STEM enrolment decisions in Year 12?" and Research Question 2 "How do background variables influence beliefs about STEM, intention towards STEM and enrolment in STEM subjects in Year 12?". The eight key factors are 'Gender and STEM', 'Socio-economic status', 'Immigrant status', 'The intersection of gender, socio-economic status and immigrant status', 'Education and career aspirations', 'Value placed on STEM', 'Classroom experiences of STEM teaching and learning' and 'Level of control over decision making'. A summary of the discussion relating to the key findings of this research is then presented in Section 6.11. Other influential factors that were not considered major findings of this study have not been extended beyond those identified in the findings presented in Chapters 4 and 5.

6.2. Conceptual framework of STEM subject choice in Year 12

In Section 2.4.10. an adapted TPB model situated within the context explored in this research is presented (Figure 2-4) as the framework guiding the study. The model was used in developing research methods that could adequately address the research questions posed at the conclusion of the literature review and the identification of gaps in the research. In particular, the structure of the multiple regression and SEMs and the placement of variables in causal order was based on the elements and structure of the adapted TPB. Results from the quantitative phase of the research, and the elements within the adapted TPB which were not reflected in those quantitative models, were reflected in interview questions used during the qualitative phase of the research. Although the TPB has previously been treated as a single level model, the nested structure of PISA/LSAY data (i.e. students within schools) required the use of multilevel analyses. Qualitative findings relating to various school level variables such as school context, school type, school location, teacher influence and peer influence added to and extended the results of the quantitative models. I argue that future research which considers the use of the TPB as the guiding conceptual framework for exploration of nested data should consider a multilevel adapted TPB. An updated adaptation of the TPB that incorporates the findings from both phases of this research is presented as a multilevel conceptual framework in Figure 6-1.

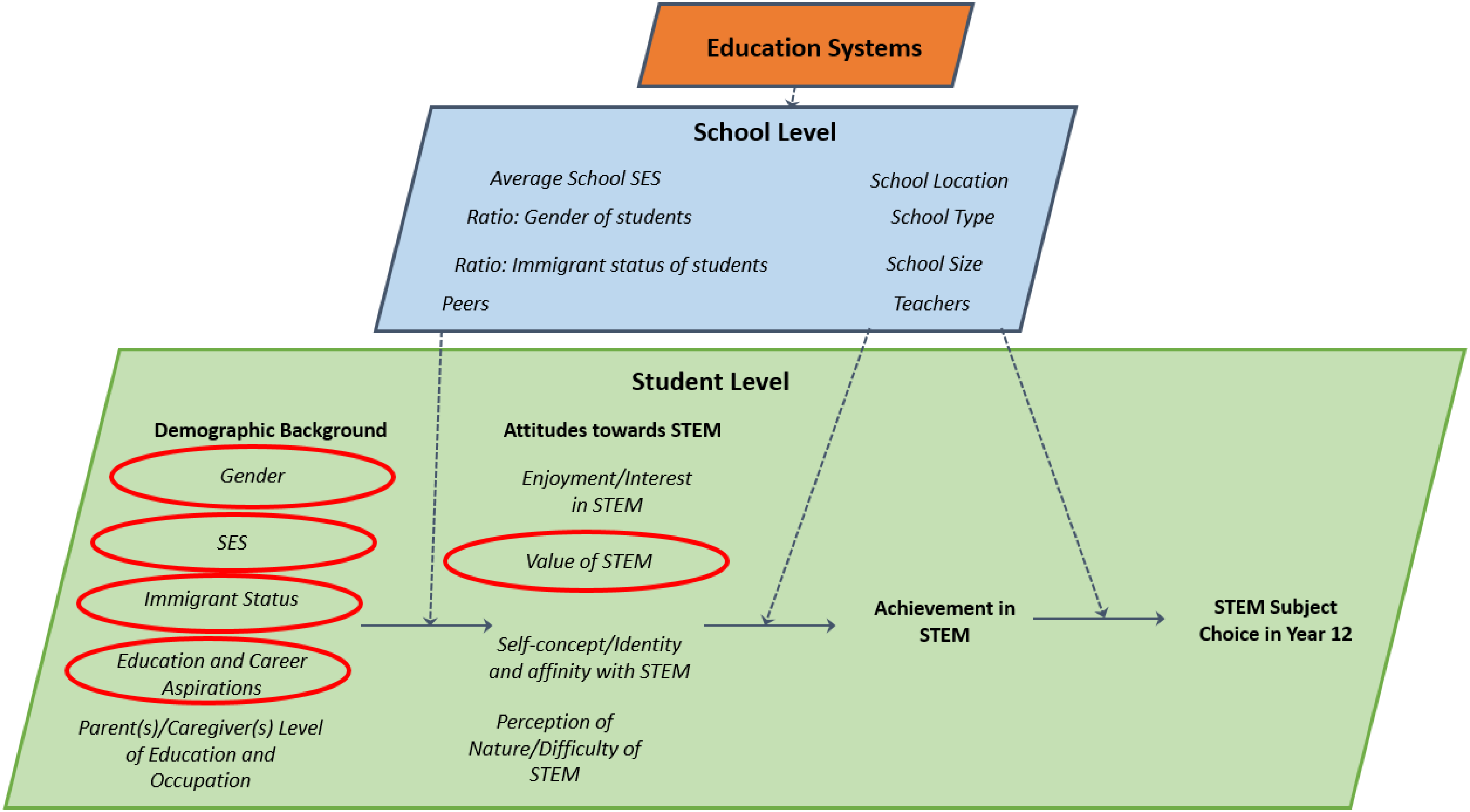

Figure 6-1. Conceptual framework of STEM subject choice in Year 12.

Figure 6-1 was developed as a result of a synthesis of findings from the quantitative and qualitative phase of the research with an adapted TPB as the guiding conceptual framework. In this conceptual framework, there are a series of interrelating relationships that were identified in either one or both of the phases of the research. Key factors to be discussed in this chapter are coloured red. Numerical values in brackets indicate the section where those factors are discussed. Clearly, a linear one-way single level model could not suffice to adequately unpack the complexities that surround the phenomena of educational decision-making. Only the most notable influential factors of interest are included in this model, although many more were briefly outlined in Chapters 4 and 5. Rather than discuss each factor in isolation, eight key concepts are discussed below. The relationships and influences of several other factors on these eight key factors are described in the remainder of the chapter. Key factors include gender; SES; immigrant status; intersection of demographic background, education and career aspirations; value placed on STEM; classroom experiences with STEM; and level of control over educational decisions. This conceptual framework acts as an advance organiser to help guide readers for the remainder of the chapter.

6.3. Gender and STEM

An abundance of literature has focussed on the gender disparity that exists in STEM education at all levels and in the STEM workforce. UNESCO has reported that the disparity begins at an early age and widens as children progress through schooling (United Nations Educational Scientific and Cultural Organization, 2017). In this research, a student's gender influences their decision of whether to enrol in a STEM subject in Year 12. The multiple regression model (Table 4-4) and the SEM (Figure 4-1) presented in the quantitative phase of the research shows that females are less likely to enrol in a STEM subject than their male counterparts. These findings add to the commonly reported gender gap in STEM in the senior years of high school. Prior research into Australian students' educational choices has shown that females are less likely than their male peers to enrol in STEM subjects in the senior years of schooling, particularly in physics and advanced mathematics (Fullarton et al., 2003; Hobbs et al., 2017; Law, 2018). However, a recent report by Marsh et al. (2019) has shown that a gender gap in Year 12 STEM enrolment does not exist, at least at the time of the data collection (2003). In fact, there was a significant positive direct effect of gender (females) on STEM subject choice in Year 12. However, the outcome variable used in the Marsh et al. study was based on a self-report of students' self-perceptions of whether they enrolled in a STEM subject in Year 12 or not. They relied on students' interpretations of what constituted a STEM subject rather than using defined categorisations of STEM based on the subjects they enrolled in, as was done in this thesis. However, Marsh et al. (2019) found that there was a zero net effect of gender on self-reported STEM enrolment, likely due to female students' less favourable attitudes towards mathematics and lower achievement levels in mathematics and science. Similar to the Marsh et al. (2019) paper, models presented in the quantitative phase of this research show that students' attitudes towards science and achievement in science and mathematics mediate the relationship between gender and STEM subject choice. Females are shown to have less favourable attitudes towards science (enjoyment, personal value and self-concept) and to have lower levels of achievement in science and mathematics, albeit a small effect, helping to explain the gender disparity. Hassan (2008) also reported that females exhibit less favourable attitudes (motivation, enjoyment, self-concept and lack of anxiety) in science than their male peers.

Prior research findings have suggested that using a binary STEM variable (encompassing multiple subjects) may be too coarse to unpack the complexity of gender differences in subject choice decisions. For example, some previous studies showed that females tended to enrol in the health, social and biological science, whilst males tended to enrol in mathematical, chemical and physical sciences (Bøe et al., 2011; Fullarton & Ainley, 2000; Marsh et al., 2019; Sikora, 2014b; Sikora & Pokropek, 2012a). In order to test the complementary nature of these findings, models developed in the quantitative phase of the current research were altered to investigate subject choice by a more fine-grained approach, using a disaggregated outcome variable. When Physics (Figure 4-2) and Biology (Figure 4-3) subject choice models were tested, the effect of gender on subject choice became more apparent. Females were less likely to enrol in Physics and more likely to enrol in Biology than their male counterparts. Similar findings in relation to tertiary levels of education have also shown that females with aspirations for science were more likely to pursue a career in biology, health or agriculture whereas science-oriented males preferred careers in engineering, mathematics or computing (Sikora & Pokropek, 2012a). The aspirations developed throughout schooling can be seen as a proxy for an intention to enrol in related subjects in senior secondary school. It is no surprise then that males were shown to be more likely to enrol in Physics whilst females were more likely to enrol in Biology in Year 12 (Sikora, 2014b). Following this trend the segregation widens further after high school with males being five times more likely to study a course in the physical sciences at university than their female peers (Sikora, 2014b). Even though recent findings by Marsh et al. (2019) were inconsistent with findings presented in this current research, they did present similar results once STEM subjects were disaggregated, finding that female students were more likely to enrol in life science subjects whilst male students were more likely to enrol in physical science subjects in Year 12, consistent with the findings of this research.

In attempting to understand the reasons for the gender disparities outlined above, a number of influential factors are considered based on findings from this research along with those outlined in prior research on gender and STEM. In the qualitative phase of this research, Jessica described how she developed a low level of self-efficacy and self-confidence in STEM (see Section 5.7.2.). In the quantitative phase of this research the multiple regression model (Table 4-4) shows that self-concept in science is a significant positive predictor of STEM subject choice. This finding is replicated in the SEM (Figure 4-1), with its influence on achievement in science and mathematics also highlighted. Aspects of the self-concept variable constructed within PISA point to the influence of self-confidence in the formation of a STEM identity. Prior research findings suggested that female students develop lower levels of self-concept in science and higher anxiety levels than their male counterparts (Hassan, 2008). A similar effect has been found for females' levels of self-confidence and self-efficacy in science even with levels of achievement accounted for (Sikora & Pokropek, 2012a). A more recent Australian study showed that females were also more likely to exhibit lower levels of self-efficacy in mathematics than their male peers (Kennedy et al., 2018). These findings raise two questions. How can schools enable young females to recognise their capability in STEM and act upon it? Or conversely, why are males so overly confident? Analyses used in this research did not address these questions explicitly. However, Jessica described in her interview both the reason for her low levels of self-efficacy in STEM, even though she had high prior achievement levels, and how she overcame it (see Sections 5.5.3. and 5.7.2.). She attributed some of her lack of confidence to the male-dominated classroom setting, particularly in Specialist Mathematics. Jessica discussed in depth how having a female friend in the classroom allowed her to overcome those self-confidence issues. Constant reassurance from her female friend, that she was competent within the subject, helped her to develop a stronger level of self-efficacy in Specialist Mathematics. Jessica also described how having another female in the class overcame her concern about being singled out, stating that if her friend had not been in the class, then she would likely not have continued in the subject. She argued that a male peer would probably lack the emotional capacity to help her through tough times and help her build the confidence needed to be successful within the topic. Many studies have examined the relationship between gender, academic self-concept and the construction of learner identity. The construction of identity and how individuals' develop an understanding of 'self' is "bounded by social structures, and … interactions shape the organization and content of self" (Tytler et al., 2008). Female students who did not have career aspirations for science were found to be influenced by their constructions of identity related to desirability and femininity (Archer et al., 2013). They described females who were passionate about science as clever/brainy, making the link between low levels of achievement and a diminished science identity clear (Archer et al., 2013). Adding to the male-dominated nature of STEM (in particular physics and advanced mathematics), prior research has shown that many topics within mathematics and physics have been taught through using examples of traditionally masculinised applications (Hobbs et al., 2017). A curriculum taught through a gendered perspective has been shown to negatively influence female students' interest in and subsequent engagement in those subjects (Hobbs et al., 2017). Therefore, it is imperative that schools pay explicit attention to evaluating STEM curriculum, particularly for a subject such as physics which has traditionally been taught through masculinised examples and applications, and make changes that focus on more gender neutral applications.

Sustained examples of gender disparities in STEM at various levels of education and careers are likely to perpetuate sociocultural norms, such as perceiving STEM as a masculine domain, which may result in the development of gender stereotypes, creating a barrier for women's inclusion in many STEM fields (Chimba & Kitzinger, 2010; Francis et al., 2017a; Hobbs et al., 2017; Holmes et al., 2017). Evidence provided by Keira in the qualitative phase of this research highlighted the impact of sociocultural norms on her parents' views on gender and STEM career pathways (see Section 5.7.2.). Keira was a recent migrant from an African nation. Her father worked as a STEM professional. Keira expressed a desire to be an engineer at an early age but was dissuaded by her father from following that pathway due to the male-dominated nature of the industry, being pushed towards a more 'suitable' career of working with children or in a medical field. Previous research has shown that the masculinised nature of gender disparate fields of inquiry has resulted in females' lack of a sense of belonging (Cheryan et al., 2017). A student's ability to develop a science identity and aspirations for a science career were shown to be influenced by the relative degree to which they subscribe to traditional gender stereotypes (Cundiff et al., 2013). If female students do not have strong aspirations for science then they may attend to those traditional stereotypes, with femininity being associated with 'nurturing' or 'girly' jobs and masculinity with science jobs (Archer et al., 2013). Misogynistic foundations have positioned positive aspects of femininity such as being caring or nurturing as the opposite of characteristics associated with hegemonic masculinity (Francis et al., 2017b). This notion was evident in Keira's transcript where she described how her parents warned her against pursuing a career in engineering, suggesting she follow a more 'suitable' pathway into a more nurturing field (medicine or education). Parents have often been shown to perpetuate gender stereotypes of science as being male-dominated and a masculine field of inquiry (Archer et al., 2013). Chimba and Kitzinger (2010) analysed media documents in the UK to show how reporters also perpetuated stereotypes through their differing portrayal of male and female scientists. Female scientists would typically be described using aspects of their physical appearance such as clothing, body shape and hair style (Chimba & Kitzinger, 2010). Male scientists would be depicted as the traditional stereotypical 'nerdy' scientist with glasses and a beard (Chimba & Kitzinger, 2010). However, a female participant in this research (Alana) showed that despite these negative influences she had a particular vision of 'who she is' and her view of 'self' would not be swayed by external influences (see Section 5.4.4.). This resulted in her continuing on a STEM pathway, enrolling in Mathematical Methods, Chemistry and Nutrition in Year 12.

Several of the female students interviewed in the qualitative phase of this research discussed the role that teachers played in helping to shape their STEM enrolment decisions entering Year 12. Prior research has shown that teachers of Junior Science were found to be very influential on the likelihood of students pursuing science in senior secondary school (Lyons & Quinn, 2010). Students in the current research often looked to their teachers as a source of advice. The encouragement as well as discouragement from a teacher can ultimately affect whether students decide to enrol in a STEM subject in Year 12. This typically occurs when teachers do not feel that the student is adequately prepared or achieving at a necessary level to continue with the subject. Eliza and Claudia both explained how a discussion with their STEM subject teachers had resulted in them dropping to a lower level STEM subject or out of the topic completely (see Section 5.5.2.). Lily described how her Biology teacher indirectly influenced her decision to discontinue studying the subject beyond Year 11. She outlined how her teacher often described the increasing difficulty of the subject at the Year 12 level and that their grades would likely not improve. Lily found this type of discussion demotivating and it negatively impacted her self-efficacy in the subject. Prior research found that females' formation of self-efficacy in STEM subjects was influenced, in part, by their interaction with classroom teachers (Heaverlo, 2011; Hobbs et al., 2017). Hobbs et al. (2017) found that teachers' expectation of success was lower for female students and they often advised them against pursuing a STEM career. Further, many in-class attributes that teachers exhibited influenced students' attitudes towards them and the subjects they teach.

Gender research has posited the effect of peer interaction on females' formation of a science identity, level of self-efficacy and general attitudes towards STEM (Hobbs et al., 2017). In-class interactions with peers and the level of help female students received resulted in a more enjoyable experience and sustained engagement in science (Oliver et al., 2017). Achievement in mathematics and subsequent enrolment in mathematics in senior secondary school was generally consistent with their peer group (Wang & Degol, 2013). This finding contrasted with the findings presented in the qualitative phase of this research. Many students provided evidence in the interviews for the lack of influence that peers had over their decisions. Often the lack of influence was linked to individuality and a recognition that the decisions they were going to make would affect their future career plans and not that of their peers. Some participants described the negative interactions they had with peers, being labelled as a ‘nerd’ due to their inclination towards STEM, but despite this, continuing to pursue their passion. Students who were perceived to be good at mathematics carried a certain stigma (Forgasz, 1994). Peers who were classified as being ‘into’ science were associated with being clever or brainy (DeWitt et al., 2013). In order to deal with these perceptions students may have developed a coping mechanism to overcome the stigma, as found by Coleman and Cross (2005). However, participants in the current research described how the label of being a ‘nerd’ did not deter them from pursuing their passions for STEM. Alana described the negative interactions she had with her friendship group but ultimately decided to continue on a STEM pathway despite their discouragement, mainly due to her sustained passion for STEM (see Section 5.5.3.).

6.4. Socio-economic status

The relationship between a student’s socio-economic background and their decision of whether to enrol in a STEM subject in Year 12 is complex. Prior research that investigated simple proportions of students from varying socio-economic backgrounds showed that high SES students were twice as likely to enrol in Year 12 physics compared to low SES students (Fullarton & Ainley, 2000). However, findings from the quantitative phase of this research, particularly the multiple regression model (Table 4-4) and the SEM (Figure (4-1) suggest that there is no direct effect of SES on STEM subject choice. However, an indirect effect is present, with the relationship between SES and subject choice operating through a set of mediating variables, namely attitudes towards science (enjoyment, personal value and self-concept) and achievement in science and mathematics. This finding is complementary to the work of Holmes et al. (2017) who found that there was an indirect relationship between SES and STEM career aspirations, mediated by attitudes towards science and achievement in science and mathematics. McGaw (2006) suggested that the effect of SES on academic achievement and subject enrolment may operate on both a school level and an individual level. Using Australian PISA 2003 data McGaw (2006) found that 70% of the variation of performance between schools could be explained by the social background of schools (30%) and the social background of individual students (40%). In an attempt to explain this variation, McGaw

(2006) investigated the enrolment patterns of students of similar ability from regions of differing average SES levels. Comparing students with similar attainment levels in state wide examinations from south western Sydney (low SES) with northern Sydney (high SES) showed that those students from the low SES region were less likely to enrol in advanced English subjects and more likely to enrol in less demanding subjects (McGaw, 2006). The reduced suite of subjects offered in south western Sydney schools compared with schools from northern Sydney helped to explain these disparate enrolment patterns (McGaw, 2006). This finding was replicated in Western Australia where students from low SES regions attended schools that had a restricted curriculum resulting in a limited ability to access university courses with pre-requisites (Perry & Southwell, 2014). The multilevel models (Table 4-11 and Figure 4-4) presented in Chapter 4 also show that the average SES of students attending a school (school level) moderates the relationship between immigrant status (student level) and STEM subject choice in Year 12. This finding is discussed further in Section 6.6.

Findings from the qualitative phase of this research highlight the importance of parent(s)/caregiver(s) educational level and occupation on students' attitudes towards STEM and subsequent enrolment in a STEM subject in Year 12. The impact that parents had on a student's curiosity and passion for STEM was described by Alana who stated that her mother's and father's education and occupation allowed her to experiment with STEM related activities from a young age (see Section 5.7.4.). Prior research has shown that high SES students typically have better access to resources (Hampden-Thompson & Johnston, 2006) and more learning opportunities at home (Wang & Degol, 2013). Samuel outlined how his father being a STEM professional and discussing his work whilst at home had allowed him to develop an interest in a related field (see Section 5.7.4.). Vidal Rodeiro (2007) reported that students typically follow educational pathways consistent with their parents, where students with parents in professional roles are more likely to enrol in traditionally academic subjects. Similarly, Edward had the opportunity from an early age to familiarise himself with STEM activities due to his father's occupation as a STEM professional, resulting in his aspiration to pursue an engineering career (see Section 5.7.4.). These findings complement those outlined in prior research. For example, a US study found that students with at least one parent working in a STEM field were 1.6 times more likely to enrol in a STEM major at university compared to those who did not (Moakler

Jr & Kim, 2014). Research in the UK showed that students tended to align their educational and occupational aspirations with their parents' type of occupation (Croll, 2008; Vidal Rodeiro, 2007). Students who had parents in professional, managerial or technical positions were more likely to aim for occupations with higher status than their peers with parents in manual or skilled non-manual occupations (Croll, 2008). Students with parents in professional occupations were also more likely to select traditionally academic subjects, reflecting a typical association between students' subject choice and their place within a socio-economic hierarchy (Vidal Rodeiro, 2007). Encouragingly, if students had aspirations for high level occupations and exhibited high academic achievement there was an equal probability of them entering high level occupations regardless of their parents' occupational status (Croll, 2008). In Australia, a similar picture was presented, with a positive correlation between parental employment in science and students' aspirations for a science career (Sikora & Pokropek, 2012b). Holmes et al. (2017) showed that having at least one parent in a STEM occupation improved the likelihood of developing occupational aspirations for work in a STEM field. Potential implications for the level of influence that parental support and encouragement can have on students entering the post-compulsory phase of schooling are addressed in Section 7.2.1.

6.5. Immigrant status

Results from the quantitative phase of the research suggest that the immigrant status of students influences whether they decide to enrol in a STEM subject in Year 12. The multiple regression model (Table 4-4) and the SEM (Figure 4-1) presented in Chapter 4 show that students who come from 1^{st} or 2^{nd} generation migrant families are more likely to enrol in a STEM subject than their native counterparts. In this research, a native student was classified as one who has at least one parent born in Australia. Prior research showed that students with parents who were born outside of Australia, and from non-English speaking backgrounds in particular, were more likely to enrol in mathematics and physics in Year 12 (Fullarton & Ainley, 2000). In the UK, 'non-white' students were found to be more likely to enrol in science subjects than 'white' students (Vidal Rodeiro, 2007). In the models presented in the current research, native students exhibit less favourable attitudes towards science and lower achievement in science and mathematics than students from migrant backgrounds. Similarly, immigrant students in the US showed higher levels of self-concept, engagement and achievement in science and mathematics (Porche, Grossman, & Dupaya, 2016).

In Australia, the disparity between attitudes, achievement and engagement with STEM between native and non-native students may be attributed to the influence of parent(s)/caregiver(s) and the nature of migrants who settle in Australia. Large-scale migration to Australia has been occurring since the end of World War 2, with skilled labour recruitment becoming an important feature since the mid-1990s (Saunders, 2008). At the time of the PISA 2006 data collection (the dataset used in this research), almost half of all migrants in Australia were classified as skilled migrants (Saunders, 2008). Migrants were over-represented in professional occupations, but under-represented in trades and technical occupations (Saunders, 2008). Findings from the qualitative phase of this research complement the notion of migrant parent influence. During this phase, six non-native participants were interviewed. A common thread relating to these students in particular was the large influence that their parents had over their decision-making process when entering Year 12. Keira described how the decision of whether to enrol in STEM was half her decision and half her father’s decision (see Section 5.6.). In an indirect way, Edward outlined how his experiences at home due to his father’s career in a STEM field had allowed him to build a fascination for applications of STEM (see Section 5.7.4.). Arun argued that the appreciation that he had for the sacrifice his parents made to create a better life for him resulted in him following in a similar pathway to his father and choosing the subjects necessary to allow that pathway to happen (see Section 5.7.4.). However, prior research showed that using a dichotomised variable for immigrant status may be too coarse. Marjoribanks (2004, 2005, 2006) suggested that differences existed in students’ educational aspirations and achievement for various cultural and ethnic groups. In the US, Asian American students achieved at higher levels in science and mathematics in Grade 10 than students from other ethnic groups (Else-Quest et al., 2013). In another study, Asian American students were also more likely to enrol in a university STEM major compared with students from other ethnic backgrounds (Sahin et al., 2017). Progression through and subsequent completion of STEM degrees by students belonging to minority ethnic communities was also influenced by parental expectations and various resources, experiences and support programs at university (Museus et al., 2011). A brief discussion of the need to investigate the influence of parents, stratified by country/region of birth, on Australian students' STEM enrolment decisions is outlined in Section 7.4.

6.6. The intersection of gender, socio-economic status and immigrant status

The results of the multilevel multiple regression model (Table 4-11) and the multilevel SEM (Figure 4-4) show that several variables on a school level influence the likelihood of students from particular demographic backgrounds participating in STEM in Year 12. The relationship between gender and STEM subject choice is moderated by the ratio of native students attending the school. The models show that females are less likely to enrol in a STEM subject in Year 12 as the ratio of native students increases. A potential explanation for these effects could be that a high proportion of native students creates an environment characterised by low interest in STEM, and that girls, when placed in such a low aspirational environment are even less likely to pursue STEM. This suggestion is speculative and requires further investigation to validate the claim.

In a similar finding, the relationship between immigrant status and STEM subject choice is moderated by the ratio of native and female students attending the school and the average SES of students within the school. The models presented in Chapter 4 suggest that native students are more likely to enrol in a STEM subject when the ratio of native students within the school increases. This finding may be addressed using the big-fish-little-pond effect (e.g. Nagengast and Marsh (2012)) where the lack of competition from non-native students, who have been shown to achieve at a higher level on average, may lead to the development of higher levels of self-concept in STEM and therefore native students may be more likely to enrol in STEM subjects. This speculation cannot be confirmed from the current analyses and warrants further investigation.

Similar to the effect of a high proportion of native students on gender, the ratio of females within a school negatively influences a native student's decision to enrol in a STEM subject. Also, the likelihood of native students selecting a STEM subject in Year 12 increases in schools where the average SES of students attending that school increases. It is hypothesised that immigrant students who attend low SES schools are likely to come from different countries than those immigrant students who attend high SES schools. The moderation effect could also suggest an aspirational dimension to the school context or climate. Little prior research was found that investigated the interaction effects between gender, immigrant status, average schools SES, ratio of school gender, ratio of school immigrant status and STEM subject choice. The findings outlined in the quantitative phase of the research relating to these moderating relationships highlight an original contribution to the field under examination. However, related research in the US explored how the intersection of gender, SES and ethnicity has influenced STEM aspirations. It was shown that by Grade 9 the proportion of white male students from high-SES backgrounds interested in pursuing a STEM career was almost 10 times higher than the proportion of black female students from low-SES backgrounds (Saw et al., 2018). As students progressed through high school, the gap widened further for white male students from high SES backgrounds compared with females from all other ethnic and SES backgrounds (Saw et al., 2018). Findings from the qualitative phase of this research complement findings from previous research on the intersection of gender and ethnicity on STEM career aspirations. As previously discussed in Section 6.3. Keira described how her experiences as a female in an African country helped shape her career aspirations and the dismissal of engineering as a suitable career path. Keira's decision to take her parents' advice and pursue a career in a medical field was a result of her parents' hesitation to encourage her to follow an engineering pathway. These ideas likely stemmed from the cultural background to which she belonged and her gender as it related to the male-dominated industry of engineering. Keira's remarks are clear evidence of the intersection between ethnicity and gender, and the detrimental effect that can have on non-native female students' aspirations for a STEM career.

6.7. Education and career aspirations

Interview responses provide evidence of the influence that a student's educational and career aspirations have on their decisions of whether to choose a STEM subject in Year 12. When the first broad opening question "How did you come to the decision to choose your subjects for Year 12?" was asked in the interviews, often the first response included some reference to post-school educational aspirations leading towards a specific career path. In order for students to pursue a particular career, they must determine the educational pathway that is necessary to reach their goals. When students are deciding which subjects to choose in the senior years of high school, they start to develop a perception of how useful each subject is relative to their intended educational and occupational pathway. Many of the participants in this research described how their desire to pursue a particular career pathway and the associated tertiary requirements were overwhelming factors in deciding whether to enrol in a STEM subject in Year 12. Vidal Rodeiro (2007) found that students' career aspirations and the perceived usefulness of subjects that were matched to those career pathways were predictive of mathematics and science uptake in Years 11 and 12. In Lyons and Quinn's (2010) study, 60% of the research sample chose a science subject in Year 11 based on university requirements and career aspirations. Several participants in the qualitative phase of this research described how their decisions to enrol in a STEM subject in Year 12 were based on whether those subjects were listed as a pre-requisite for the courses they planned to study at university.

Prior to deciding which subjects to choose for Year 12 students generally have an extended period of time to think about their options and discuss potential pathways with teachers, peers and parents. Their experiences throughout schooling and at home indirectly influence their attitudes towards STEM, and as they get closer to the end of formal schooling they will usually have a clearer understanding of their educational and occupational aspirations and the pathway that is needed to pursue them. Many participants in this research felt that the decision of whether to enrol in a STEM subject in Year 12 was entirely their decision. However, interview participants described the interactions and discussions they had with their parents and outlined how they directly or indirectly influenced the decision-making process. Some participants provided very limited evidence of parental influence stating simply that their parents didn't mind what they studied as long they were confident that their child had considered all options and made a conscientious decision. However, the conversations some participants had with their parents didn't always go smoothly. Emily described the lack of a consistent message received from her parents where her mother in particular would on one occasion be happy for her daughter to drop out of school if she wished but on other occasions would tell her exactly what she should do (see Section 5.5.1.).

Students entering subject selection often discuss their intended subject choices with their parent(s)/caregiver(s). This can result in direct and indirect influences of advice and pressure to act in one way or another. A child's aspirations for science and formation of science career aspirations are shaped by these experiences with family (Archer et al., 2012). Normative beliefs set boundaries on what children believe is possible for them, ultimately affecting their likelihood of following a science pathway. However, these effects were not straightforward, with students whose parents were working in a science related job being twice as likely to hold science career aspirations as those who were not (DeWitt & Archer, 2015). The advice and/or pressure that parents placed on their children to study mathematics influenced intention and enrolment in senior secondary mathematics subjects and intention to enrol in a university level mathematics course (Sheldrake et al., 2015). Taylor (2015) found that students' normative beliefs were positively associated with students' intentions to enrol in post-compulsory physics. In particular, their perceptions of parental expectations for them to enrol in physics were predictive of the intention to enrol in physics in the final two years of schooling (Taylor, 2015). A study in NSW found that 90% of students in the sample who held STEM career aspirations, had parents who held aspirations for them to complete a university degree (Lloyd et al., 2018). Arun was heavily influenced by his parent's desire for him to follow his passion, achieve at a high level and succeed in whichever path would make him happy. He described in the interview that he was extremely appreciative of the sacrifice that his parents made for him to move to a new country and he saw his success in school and in his future career as payback for that sacrifice (also see Section 6.5.).

6.8. Value placed on STEM

Findings from both the quantitative and qualitative phase of this research show that the personal and societal value that students place on STEM ultimately affects whether they decide to follow a STEM pathway to Year 12. All participants who were interviewed in the qualitative phase of the research described how valuable STEM was for the continuing development of the society they were placed within. Many of the examples they provided to emphasise this point were related to the importance of applications of STEM and workers within STEM fields in the rapidly changing technological world (see Section 5.4.9.). Using results from the multiple regression model (Table 4-4) and SEM (Figure 4-1), it can be seen that students who value science highly in their everyday lives are more likely to enrol in a STEM subject in Year 12 than their counterparts who do not value science. Evidence is also provided in the interviews which highlights the importance of valuing applications of STEM in their personal lives (see Section 5.4.8.). Many skills identified through participants' responses are developed through studying STEM subjects in senior grades, such as problem solving and critical thinking, whilst providing them with a general grounding in necessary skills for post-school life and in understanding the world around them and 'how things work'. In a US study, Else-Quest, Mineo and Higgins (2013) found that students' perceptions of the value of the knowledge likely to be gained in science and mathematics topics beyond Year 10 was predictive of achievement in those subjects. If a student does not value STEM in their personal lives then they are less likely to continue studying STEM in the post-compulsory years of schooling. Dylan and Eliza described how they perceived particular STEM subjects that they undertook in Year 11 to have no relevance to their lives outside of the classroom and they subsequently dropped those subjects for Year 12.

Results from the quantitative and qualitative phases of the research suggest that students' prior achievement in STEM subjects influences their enrolment in STEM subjects in Year 12. The multiple regression model (Table 4-4) and the SEM (Figure 4-1) presented in Chapter 4 show that there is a positive relationship between achievement in science and mathematics at age 15 years and STEM subject choice in Year 12, i.e. those students with higher achievement are more likely to enrol in a STEM subject than those who achieve at lower levels. Many studies have shown that students' prior achievement influences the likelihood of them enrolling in a STEM subject in the senior years of schooling (Ainley et al., 2008; Fullarton & Ainley, 2000; Gill & Bell, 2013; Vidal Rodeiro, 2007). Fullarton and Ainley's (2000) research showed that students with higher levels of literacy and numeracy were more likely to enrol in physics and chemistry in Year 12 than their peers with lower attainment levels. Later work by Ainley and colleagues (Ainley et al., 2008) showed that prior performance in mathematics was predictive of chemistry and physics enrolment in Year 12. In the UK, prior achievement in mathematics, physics, biology and chemistry was predictive of students' decisions to enrol in those subjects in the post-compulsory stages of schooling (Vidal Rodeiro, 2007).

The effect of prior achievement on educational choice is also present after high school, with students who achieved highly in mathematics being more likely to enrol in a STEM major at university (Lee, 2011). Anecdotal evidence from the interviews in the qualitative phase of the research complements these findings. Brodie described how his prior high performance in STEM gave him the confidence to handle the increased workload and perceived difficulty of the subjects going into Year 12 (see Section 5.7.6.). Lily explained how her inconsistent prior performance in mathematics during Year 10 studies diminished her self-confidence resulting in her dropping mathematics at that level for her senior years of schooling. Previous research has also described how the decline in enrolment in science and mathematics subjects is likely impacted by the perceived difficulty of those subjects (Potvin & Hasni, 2014). Students' perception of performance in physics, which was influenced by prior achievement and perception of difficulty, was shown to be predictive of sustained engagement and intention to pursue physics beyond the post-compulsory stages of schooling (Abraham & Barker, 2014). Lyons and Quinn (2010) described how on a surface level subject difficulty affected the likelihood of students choosing science, with 45% of the science non-choosers within the cohort studied agreeing that their decision was based on relative subject difficulty.

Arun described how the ATAR scaling process along with the perceived difficulty of enrolling in particular STEM subjects affected his decision of whether to enrol in them in Year 12 (see Section 5.4.7 and Section 5.7.1.). He described how the perceived workload that would likely be associated with Specialist Mathematics or Mathematical Methods dissuaded him from enrolling in them. Arun explained that enrolment in both mathematics subjects would result in him needing to sit two externally assessed examinations at the end of the school year. He felt that the challenge of completing two 'high stakes' examinations on top of the usual workload would be too much of a challenge for him. Arun justified his decisions by arguing that his ATAR was likely to be maximised by achieving at a high level in subjects that would either not be scaled or scaled down as opposed to achieving at a low level in a subject that may be scaled up. Arun did not enrol in any STEM subjects in Year 12. All subjects undergo scaling procedures (South Australian Tertiary Admission Centre, 2016) and more difficult subjects (Chemistry, Physics, Mathematical Methods and Specialist Mathematics) are usually positively correlated with higher ATAR rankings (DUX College, 2016). Arun utilised a strategy that Lyons and Quinn (2010) referred to as utility value versus relative cost value where students rank subjects based on a comparison between utility value (pre-requisites and ATAR scaling tendencies) and relative cost value (time, effort and expectations of success). Mixed methods research by Marsh et al. (2019) used PISA/LSAY 2003 data to show that the utility value (educational/occupational opportunities and financial gain) that students placed on STEM subjects was instrumental in their decision to enrol in STEM subjects in Year 12 and continue into university degrees. However, the utility value of STEM subjects has recently declined due to the removal of many subjects from pre-requisite lists (Lyons & Quinn, 2010). In fact, Pitt (2015) claimed that students could potentially maximise their ATAR scores by taking easier courses. The current ATAR algorithm allowed for students (on average) to gain higher scaled scores by achieving high level results in a lower level mathematics subject compared with students who attained lower achievement in a high level mathematics subject (Pitt, 2015). Following reports such as this and past experience with ATAR scaling, there is a commonly held belief among some teachers that an ATAR can be maximised by electing to enrol in one mathematics subject rather than two (Hine, 2018).

Some students described how they have decided to choose particular STEM subjects due to their utility value as being pre-requisite subjects for entry into university courses and due to their perceived benefit for Australian Tertiary Admission Rank (ATAR) scaling. Many STEM university degrees require at least one STEM subject to be completed in Year 12 in order to gain entry into them (South Australian Tertiary Admission Centre, 2015). Hayden cited an ability to ‘keep his options open’ as being important, resulting in a selection of STEM subjects that were often pre-requisites for entry into university courses, adding a utility value to STEM subjects (see Section 5.7.1.). This was particularly useful for students who did not have set goals in mind and were unsure of their educational and occupational aspirations (Atweh et al., 2005). Even students who had developed clear aspirations described how it was beneficial to be selective of subjects typically listed as pre-requisites, as they may change their mind by the end of Year 12 or after formal schooling (Atweh et al., 2005). Worryingly, the number of high level STEM subjects listed as pre-requisites for entry into many university courses throughout Australia has declined (Innovation and Science Australia, 2017).

Certain other values that students place on STEM can be attributed to traits that relate to their identity and affinity with STEM. Results from the qualitative phase of the research showed that several students possessed altruistic qualities and had a passion for learning about people and how the human brain works, citing these qualities as reasons for wanting to study STEM (see Section 5.7.3.). Scarlett emphasised that she wanted to study Psychology in order to understand herself better and the interactions that she had with other people and wider society. A number of students who were interviewed had career aspirations for military service, medicine or psychology, and stated altruistic reasons for wanting to do so. Suchitra's experience in her home Asian country had given her an appreciation for her position within society and ability to gain the necessary STEM skills to help the community she grew up in. Emily highlighted how her own experiences with a psychologist had resulted in a passion for wanting to follow that career path. Jessica outlined how her father's motor vehicle accident and the treatment he received changed her outlook on life and she wanted to pursue medicine in order to help people in need. A recent US study found that altruism was a mediating factor between femininity and STEM choice (Wegemer & Eccles, 2019). It found that altruism and femininity helped to explain the gender disparities between choice of particular STEM fields, with females more likely to enrol in life sciences and not in physical sciences (Wegemer & Eccles, 2019). In a review examining the current state of knowledge relating to the STEM gender gap, Wang and Degol (2017) found that females were more inclined to socially oriented careers due to the altruistic nature of the work and desire to help others. They suggested that even females within STEM fields were "more likely to choose degrees that emphasize community or are people-oriented" (Wang & Degol, 2017, p. 6). A more in-depth discussion of gender disparities in STEM and the effects of gender construction and femininity was provided in Section 6.3.

6.9. Classroom experiences of STEM teaching and learning

Prior experience with STEM teaching and learning within the school setting is predictive of future engagement with STEM. Results from the quantitative phase of the research suggest that enjoyment of science is a predictor of students' achievement in science and mathematics and subsequent enrolment in STEM in Year 12. The multiple regression model (Table 4-4) along with the SEM (Figure

4-1) with STEM subject choice as the outcome variable show that those who exhibit higher levels of enjoyment in science are more likely to enrol in a STEM subject in Year 12. These findings complement previous research which investigated how students' levels of enjoyment in subjects predicted engagement with and subsequent enrolment in those subjects. Students' enjoyment of STEM subjects in the earlier years of secondary schooling was an indicator of their likely intention (Kennedy et al., 2018) and future enrolment in those subjects at Year 12 (Marsh et al., 2019; Sheldrake et al., 2015; Vidal Rodeiro, 2007). Results from the qualitative phase of the research also provide evidence that suggests the level of enjoyment students have for STEM subjects based on their previous experiences improves the likelihood that they enrol in a STEM subject in Year 12. The enjoyment of STEM or lack thereof was one of the most commonly cited reasons for interview participants deciding whether to enrol in a STEM subject. Associated with their enjoyment were levels of happiness and the perception of how boring or exciting a topic was. Scarlett described how she was achieving at a high level in Specialist Mathematics but ultimately decided not to enrol in mathematics at that level in Year 12 because she simply did not enjoy the subject (see Section 5.4.1.). Evidence was also provided in interviews that the level of interest that students have for topics covered within STEM subjects at school and general interest in STEM education affected their willingness to continue with STEM in Year 12 (see Section 5.4.2.). Similar findings have been reported previously where a student's level of interest in STEM subjects was predictive of their future enrolment in those subjects (Köller et al., 2001; Marsh et al., 2019). Some participants of this research described how they had always had an interest in applications of STEM from an early age and that earlier fascination continued to fuel their curiosity and interest in STEM in the senior years of school. However, sustained interest in STEM was not necessarily consistent among all students as contrasting reports have shown that interest in STEM (on average) subjects declines throughout secondary school (Potvin & Hasni, 2014; Sadler et al., 2012).

Many of the interview participants in the qualitative phase of the research discussed the effect of teachers on their attitudes towards and continued enrolment in STEM subjects (see Section 5.5.2. and Section 5.7.7.). An important factor that was highlighted by participants in the qualitative phase of the research was the avoidance of particular teachers that students knew would likely be teaching the topic in the following year level. This was either due to their prior experiences in the topic or through advice given to them by peers. Not only did students avoid teachers that they disliked (based on either past experience or reputation), but they chose subjects that particular teachers were taking based on their perception of being student-friendly (Atweh et al., 2005). Anna described how previous negative experiences with STEM teachers had made her decline from choosing those subjects whilst on exchange from a Western European country (see Section 5.7.7.). Luke described how the continued disappointment with his mathematics teachers over his years of schooling and the lack of encouragement provided to him resulted in him not choosing the subject at the senior secondary level (see Section 5.7.7.). The level and type of support that a teacher provides in a classroom seems to affect the experience that students have and will likely impact their general attitudes towards the topic. The motivating styles of STEM teachers, including their level of support for student autonomy, classroom structure and student involvement was shown to be associated with collective student engagement (De Loof et al., 2017). Along with engagement in STEM classes, students' levels of self-determined motivation were also shown to be influenced by teachers' support for autonomy and effective classroom structure (De Loof et al., 2017). Bennett and Hogarth (2009) found that students' perceptions of activities that teachers used in the classroom were the most important school science factor (60%) in developing students' interest in science. Other science teacher related influences such as level of enthusiasm, quality of explanation and 'being made to think', were positive factors in students' attitudes towards science (Bennett & Hogarth, 2009). The manner in which STEM subjects have traditionally been taught influences the experiences that students have and ultimately their attitudes towards and achievement in STEM. This affects the likelihood of them continuing to enrol in STEM subjects beyond the compulsory stages of schooling. Students who have a perception that their classroom teachers are of high quality and incorporate effective pedagogy generally state that they enjoy the subject regardless of its difficulty. For example, Eliza described how a pre-service teacher who was able to utilise different teaching strategies to cater for students of differing abilities and learning styles for success altered her previously negative perceptions of the subject (see Section 5.7.7.). Science and mathematics subjects were often seen by students and teachers as tailored towards university preparation (Goodrum, Druhan, & Abbs, 2012). This shifted the focus of teachers to an attempt to ‘get through’ the exorbitant amount of content specified in the curriculum (Goodrum et al., 2012). In an attempt to cover all the content, teachers relied on traditional models of transmissive teaching (Goodrum et al., 2012). In the interest of saving time, students generally copied notes, viewed a teacher-led demonstration, participated in ‘recipe’-like investigations with known answers, in turn reducing the flexibility of teachers to engage students in open-ended interest-based investigations (Goodrum et al., 2012). The pedagogical approach of teachers, coupled with the general nature of STEM and concepts typically covered in STEM classes, was influential in the STEM subject decision-making process.

During interviews for the qualitative phase of the research participants discussed the perceived difficulty of STEM subjects and the general nature of STEM and how that suited their preferred learning style. Participants described how they had a natural affinity for the definitive nature of STEM and preferred the lack of variability in possible solutions for many problems explored in STEM subjects. Eliza outlined how the changing nature of STEM subjects and curriculum specificity from earlier years of high school through to the senior years resulted in a loss of interest in STEM education entirely (see Section 5.4.5.). She addressed how general science in earlier years was interesting as it covered a wide variety of topics, where the typical ‘silo’ approach to STEM in the senior years was of less interest to her. Others simply did not like the amount of ‘textbook’ type learning that they had previously experienced in STEM subjects, preferring ‘hands on’ learning in more practical subjects. Hogan and Down (2015) argued that there were a number of problems with the current construction of STEM teaching in schools, resulting in the downward trend of enrolment in STEM education. The problems presented to students in STEM classrooms and the experiments undertaken were not meaningful or relevant to their personal everyday lives (Hogan & Down, 2015). Hogan and Down (2015) suggested that STEM curriculum needed to be reconceptualised to ensure that learning was situated within an authentic context and was relevant and rigorous (Hogan & Down, 2015). Emily extended the discussion about the lack of perceived usefulness for STEM subjects in a rural area (see Section 5.4.8.). She argued that many of the concepts taught in mathematics were irrelevant as they were perceived to not be needed beyond the school setting. Emily felt as though her teachers did not explain the applicability of concepts covered in mathematics and were simply doing it for the ‘sake of it’. She clearly explained how she had a desire for her teachers to explain how these concepts could be used in students’ everyday lives. Without the perceived value of STEM subjects, students are unlikely to enrol in them beyond the post-compulsory stages of schooling.

6.10. Level of control over decision making

Findings presented in the qualitative phase of this research further highlight the influence that school context has on students’ desire to pursue STEM beyond the compulsory stages of high school. Small rural and regional schools are often faced with a number of barriers due to the size of the school that result in limited access to the full range of SACE subjects. The lack of staffing associated with low student enrolments and therefore lack of timetable flexibility was a reason for the students from the rural school participating in this research being forced to choose between two of their preferred subjects. The difficulties that rural schools, along with schools in remote Indigenous communities and schools from low-SES regions, faced were common (Marginson et al., 2013). The report from the Staff in Australia’s Schools (SiAS) survey 2013, which used responses of 10,349 teachers from 511 schools, showed that on the first day of Term 1 8.7% of schools had at least one unfilled mathematics position and 5.9% of schools had at least one unfilled science position (McKenzie et al., 2014). Although students attending rural schools typically have the option to complete a course in an online mode, the lack of face-to-face teaching and classroom support is often perceived as too difficult for many students. Another issue facing many rural and remote schools is the inability to attract suitably qualified teachers for all the subjects offered within the school. Tahlia described how her Year 11 teacher was going on maternity leave and the school was unable to backfill her position so the subject was simply not offered, even though they had the necessary number of students to satisfy the usual class size requirements (see Section 5.7.5.). In order to account for shortages of suitably qualified teachers in schools, 15% of secondary school principals (in the SiAS sample) stated that they reduced the number of topics offered to students (McKenzie et al., 2014). Tahlia went on to explain another barrier that she faced in her Biology and Chemistry classes was the use of vertical classes, where Year 11 and Year 12 cohorts were combined, resulting in certain complexities that made effective learning difficult. In the SiAS report, it was stated that classes were combined across year levels (vertical classes) in 11.6% of schools (McKenzie et al., 2014). Many troubling teacher recruitment strategies were also highlighted in the secondary principal responses, such as recruiting teachers to teach outside of their field of experience (33.2%), teachers with a lack of suitable subject qualifications (19.4%), and recruiting retired teachers to re-enter the workforce on short term contracts (9.3%) (McKenzie et al., 2014). The shortage of suitably qualified science teachers in Australian schools is one of the key factors that has resulted in the ‘crisis in science’ (Tytler & Osborne, 2012).

The issue of enrolment numbers and the resulting reduced class sizes in many rural, regional and remote schools is shown to reduce the likelihood of students who attend those schools enrolling in STEM subjects. Previous research has explained how the size of a school influenced the variety and number of subjects that a school could offer to students (Legewie & DiPrete, 2014; Smyth & Hannan, 2006; Spielhofer et al., 2002; Vidal Rodeiro, 2007). STEM subjects that were perceived to be difficult, and generally had lower enrolment numbers than others, were the most affected, with chemistry, physics and mathematics being less likely to be offered in small schools (Smyth & Hannan, 2006; Spielhofer et al., 2002). If a school could not offer a subject that a student wanted to study then they had the option to move schools, as 16% of participants in Vidal Rodeiro’s (2007) research indicated they did. However, this is not an easy task for some students. Students from rural, regional and remote communities cannot simply move to a different school. They may be hundreds of kilometres from the nearest school in a regional centre that has a greater range of subjects available to students. The flow on effect of a lack of high level STEM subject offerings can result in students’ unwillingness to pursue STEM pathways beyond formal schooling. Legewie and DiPrete (2014) found that a school’s ability to offer high quality advanced STEM subjects increased the likelihood of students developing STEM education aspirations, with plans to major in a STEM field at university. Rural, regional and remote students face many barriers which influence the level of control they have over the decision of whether to enrol in STEM in Year 12.

Results from the quantitative phase (see Figure 4-4) of the research show that school location moderates the relationship between gender and subject choice, where females are more likely to enrol in STEM when they attend a rural school compared with a metropolitan school. This finding is complementary to Fullarton and Ainley's (2000) research that showed the proportion of female students taking mathematics was higher in rural areas compared to cities. Participants from the small rural school in this research described at length the barriers that they faced in choosing their subjects in Year 12 (see Section 5.7.5.), some of which were discussed in that section. This begs the question: why do rural students have so many barriers to pursuing STEM but female students find a way to overcome them, as the result from the quantitative phase of the research shows? Is it a reflection on female students in metropolitan schools rather than female students from rural areas? This could mean one of two things. First, even though students from regional, rural and remote schools face a unique set of circumstances that are barriers to pursuing educational and occupational pathways in STEM, female students from these schools are persistent. Second, female students from metropolitan schools are disproportionately declining to follow pathways into STEM despite the perceived lack of the barriers that female students in regional, rural and remote schools face. However, the converse effect cannot be ignored. Male students from rural schools are not developing STEM career aspirations, which results in declining enrolments in STEM subjects in Year 12. These hypotheses were not tested in this research but warrant further investigation in future research.

6.11. Summary

This chapter has provided a synthesis of the quantitative and qualitative findings presented in Chapters 4 and 5. Further, these results were situated within prior research findings as either complementary or contrasting. As a result of this synthesis, the adapted TPB conceptual framework that guided the study was reconceptualised to be considered as a multilevel model. It was argued that future researchers who are using the TPB to examine nested data should utilise an adapted multilevel TPB for analyses. The remainder of the chapter discussed eight key findings of the research and their relationship with numerous other influential factors of interest. These included issues related to gender, SES, immigrant status, the intersection of these demographic characteristics, aspirations for education and careers in STEM, the value students place on STEM, prior classroom experiences with STEM teaching and learning, and the level of actual control that students have over educational decisions based predominantly on school constraints.

7. CONCLUSION

A review of the literature (Chapter 2), that focussed on educational choice in the STEM context, provided an overview of the complexity of the decision-making process that students go through when navigating their way through compulsory schooling, post-school study and into the work force. The political and societal desire to increase the number of STEM-literate citizens was highlighted by the often-cited STEM skills shortage and the forecast benefit to the economy as a result of increasing the number of students entering the STEM workforce. Theories of behaviour and choice were presented, and the theory of planned behaviour (TPB) was chosen as the conceptual framework that guided the review of literature concerning educational choice, methodological design, analysis and interpretation of results. Alternative theories such as social cognitive career theory (SCCT) and expectancy value theory of achievement motivation (EVT) were considered. However, elements described in the TPB matched the purpose of the research and the anticipated factors of influence based on a review of the literature. Previous research was examined relating to the constructs indicated by the TPB to be influential in choice-related behaviour, namely intention, attitudes, perceived norms, perceived behavioural control and background factors. As a result of this review a number of gaps in the reviewed research were identified and research questions developed from this:

1. What factors (student and school) influence students' STEM enrolment decisions in Year 12?
2. How do background variables influence beliefs about STEM, intention towards STEM and enrolment in STEM subjects in Year 12?

In order to design the methods needed to address these research questions, a pragmatist worldview was adopted and a mixed methods approach was deemed appropriate to address both overarching research questions with a postpositivist lens used for the quantitative phase of the research and an interpretivist lens used for the qualitative phase of the research (Pring, 2015). The collection and analysis of both quantitative and qualitative data allowed for the researcher to identify factors that influence Australian students' decisions of whether to enrol in a STEM subject in Year 12 and then to gain a more in-depth understanding of the decision-making process. In the quantitative phase, secondary data from PISA/LSAY 2006 was used. The software package IBM SPSS 23.0 (IBM Corp., Released 2015) was utilised to prepare the data and conduct preliminary descriptive analyses. Hierarchical Linear Modelling Version 7.4 (HLM) (Raudenbush et al., 2013) was used to develop multilevel regression models whilst Mplus Version 7.4 (Muthén & Muthén, 1998-2012) was used to develop structural equation models (SEM). A series of single level (student) and multilevel (student and school) multiple regression models and SEMs were developed and presented in Chapter 4. These results were predominantly used to address Research Question 1. In the qualitative phase of the research, 20 students from schools across rural and metropolitan South Australia participated in one-to-one interviews, which were audio recorded, transcribed and analysed using a combination of inductive and deductive thematic analysis. This process involved transcripts being coded, followed by patterns between codes being identified within and across participants, then themes were developed. Themes were named and outlined in Chapter 5 with qualitative evidence (text segments) provided for each of the identified themes. In Chapter 6, the major findings from both phases of the research were synthesised and discussed.

7.1. Major findings

My original contribution to knowledge is in the development and presentation of a synthesis of results that helps to explain how students might navigate the STEM subject decision-making process entering Year 12. The major findings based on the evidence provided in Chapters 4 and 5 are presented below:

- Clear evidence of differences in the propensity of students of various demographic backgrounds to enrol in STEM has been provided. Predominant differences exist in relation to gender, with males more likely than females to enrol in a STEM subject in Year 12. An indirect effect exists in the relationship between SES and STEM subject choice in Year 12, mediated by attitudes towards science and achievement in science and mathematics. Immigrant status was also shown to be a significant predictor, with native students being less likely to enrol in a STEM subject in Year 12 than students from migrant backgrounds. Although the stark differences between students from differing backgrounds is clear, the overall picture is more complex. As students progress through schooling, the experiences they have, which are influenced by social and cultural backgrounds, shape their dispositions towards STEM. Many other influential factors emerge as they progress through school and are outlined below.

- Attitudinal constructs such as enjoyment of science, self-concept in science and personal value of science vary based on demographic background, which then influence the likelihood of enrolment in a STEM subject in Year 12. That is, these constructs mediate the relationship between demographic characteristics and enrolment in STEM. Other attitudinal factors (interest, self-efficacy, self-confidence, perceived difficulty and societal value of STEM) were shown to influence students' decision making in the qualitative phase of the research.

- In both the quantitative and qualitative phase of the research, achievement in STEM is shown to influence the STEM enrolment decisions of students entering Year 12. Prior achievement in STEM subjects differs depending on demographic background and a reciprocal relationship likely exists between attitudes towards STEM and achievement in STEM subjects. Higher achievement levels in STEM subjects ultimately increases the likelihood of a student enrolling in a STEM subject in Year 12.

- Students' perceived norms are affected by the experiences they have with peers, parents and teachers. These experiences differ depending on students' demographic background and are also shown to influence the likelihood of enrolment in a STEM subject in Year 12.

- In the qualitative phase of the research, one of the most commonly cited responses to the opening question "How did you come to the decision to choose your subjects for Year 12?" was related to education and career aspirations. Many participants described how university pre-requisites and ATAR requirements influenced their decisions of whether to enrol in a STEM subject in Year 12. Although some students are not sure of an education and career pathway by the time they enter Year 12, many have developed aspirations for a particular field of inquiry. It is hypothesised that once STEM career aspirations become clear, students begin to form an understanding of the educational decisions that need to be made in order to pursue that pathway. Students could then strategically choose subjects based on the comparative differences between utility value and relative cost and this ultimately influenced the likelihood of them enrolling in a STEM subject in Year 12.

- Moderating all of these relationships and interactions between factors of influence stated above are a number of school related factors. In the quantitative phase of the research, school type (location, average SES, and ratio of students by gender and immigrant status) moderated the relationship between demographic background (gender and immigrant status) and STEM subject choice in Year 12. In the qualitative phase of the research, the experiences students had in the classroom, particularly with STEM teaching and learning, influenced the development of their attitudes towards STEM, perceived norms, aspirations for STEM careers and the overall value they placed on STEM. School context factors such as class sizes, number and variety of subject offerings and ability to attract suitably qualified teachers influences the level of actual control students have over their subject choice decisions, particularly in small rural schools.

Although many more influential factors were outlined and discussed in Chapters 4, 5 and 6, the major findings presented in this section explain the decision-making process of students deciding whether to enrol in STEM subjects as they enter Year 12.

7.2. Implications of the findings

The major findings presented in this chapter have numerous implications for the key stakeholders in the context of research into STEM subject choice in Year 12. High school students and their families are often faced with difficult decisions during senior secondary schooling. There are a number of implications for students based on the development of perceived norms, shaped by teachers and parents, which influence how they navigate this critical time in their lives. It is important for teachers, course and career counsellors and school leaders to better understand how students navigate the Year 12 enrolment process and the resultant implications for staff in schools. The implications of the findings for these key stakeholders are outlined in Sections 7.2.1. and 7.2.2.

7.2.1. Implications for students and their families

The synthesis of the major findings from this research presented in the previous section provides school students with an account of the factors that may influence their STEM subject choice for Year 12. Findings from the qualitative phase of the research show how interactions and discussions with peers, parents and teachers influence their educational decisions. Results from the models presented in the quantitative phase also explain the moderating effect of school related factors on students' decision making. Together, these various factors enable hypotheses to be generated about ways in which teachers and parents might engage in conversations with students and assist in their decision making. If students are more aware of the factors that might influence their decisions and the mediating and moderating relationships between the different influencing factors, they may have the knowledge to begin to unpack their own thought processes that lead to educational decisions. Once students are able to inform themselves of the factors that influence the educational pathways they pursue, it could be useful for them to undergo a process of introspection or self-reflection. However, students are typically unable to fully comprehend the mechanism by which dispositions for a particular behaviour emerge (Bortolotti, 2009). Even if they cannot elaborate on the complexity of the mechanism by which they formulate a particular disposition, they may be able to give thoughtful reasons behind their attitudes and decisions, providing them with a sense of control over the decision-making process (Bortolotti, 2009). In this context, students should be encouraged to gain a better sense of the factors that influence their own decision-making process to be able to make more effective decisions relating to their future educational and career pathways. The quality of those introspections and the ability to deliberate on a variety of influential factors will determine the quality of their reasoning, resulting in either a reaffirmation of a choice or a change in direction (Bortolotti, 2009).

A finding from the qualitative phase of the research that has particular implications for students is the influence of parents and teachers and the resulting perceived norms that are developed as a result of interactions with the key stakeholders. Several examples were provided in Chapter 5 that outlined how conversations with parents and the feeling of pressure directly resulted in changes to students' education and career aspirations, sometimes away from high-level STEM. Parents' aspirations and expectations for their children influence students' dispositions towards particular pathways, as discussed in Section 6.4. Keira described in her interview how her mother and father (a STEM professional) discouraged her from following an engineering pathway, instead encouraging her towards a more 'suitable' medical pathway (see Section 5.5.1. and 5.7.2.). Teachers were also cited by participants as having both a direct and indirect influence over their decisions of whether to continue enrolling in STEM subjects beyond Year 11 (see Section 5.5.2.). Eliza outlined in her interview how her Year 11 Biology teacher dissuaded her from continuing into Year 12 Biology using a direct method, stating that it would be unwise for her to continue in the subject based on her current grades. Lily's Biology teacher used a more indirect method, continually mentioning to the class how difficult the next step up (into Year 12 Biology) was going to be and that their grades were unlikely to improve. Students and families need to understand the level of influence that parents and teachers can have over students' thinking and decisions relating to enrolment in STEM subjects in Year 12. Parents in particular are encouraged to develop a greater understanding of the variety of factors that may influence their children's decision-making process and help them to make considered and appropriate decisions that will likely lead them to a suitable career.

Children should be encouraged to pursue education and careers in fields about which they are passionate. Many students lose the passion for STEM as they move through their years of schooling, often due to the changing nature of the STEM classroom to a more rigorous/traditional mode of teaching. This may be coupled with stalling or declining achievement, in turn decreasing motivation and an affinity for the area. In her interview, Eliza outlined how the changing nature of STEM education from the earlier years into the senior years of secondary school resulted in her deciding not to continue with Chemistry, Biology and Mathematical Methods into Year 12. Eliza raised the issue of moving from general science in the earlier years, where a diverse range of concepts was covered, to the 'silos' approach of discipline-specific subjects in Year 11 and 12, leading her to move away from STEM altogether. More work needs to be done to encourage students to pursue their passions and support them to achieve at the highest level possible within those fields. When the time comes for students to choose their subjects for Year 12 study, subject counsellors often discuss with students the careers they want to pursue after school and the educational decisions that are needed to help them follow that pathway. In general, this is a useful strategy but findings from this research suggest a more intricate understanding of the decision-making process students go through is needed. Students should list the advantages and disadvantages of each subject based on a balance between their enjoyment/interest in the subject, prior achievement and aspirations for future education and careers.

7.2.2. Implications for teachers and schools

A number of the findings highlighted in this research have implications for teachers and school leaders. Students are shown to be influenced by interactions with and advice given by teachers, resulting in perceived norms that either attract them towards or direct them away from enrolment in STEM subjects in Year 12. Participants in the qualitative phase of the research described how discouragement from continuing to pursue a particular subject from Year 11 into Year 12 was one of the main reasons for them not enrolling in the subject. The experiences that students (particularly girls) have with STEM teachers throughout their schooling is likely to help shape the development of a student's STEM identity and the likelihood of them pursuing that pathway beyond the compulsory stages of schooling (Hobbs et al., 2017). Many issues that students from the small rural school who participated in this research, faced was the narrow range of subjects available to them for Year 12. This was due to a combination of the school's enrolment numbers and subsequent lack of timetable flexibility, inability to attract suitably qualified staff to the region, and inability to replace staff who were on maternity leave (see Section 5.7.5.).

Findings from both phases of the research highlight the importance that students place on the value of STEM in their decision of whether to enrol in a STEM subject in Year 12. Models presented in Chapter 4 show that students' personal value of science is predictive of achievement in science and mathematics and enrolment in a STEM subject in Year 12. It could be argued using findings from interviews that the personal value that students place on STEM is influenced by their understanding of the 'Nature of STEM'. The often-cited style of learning that is utilised in STEM classrooms was a factor that students in the qualitative phase outlined as being influential in their attitudes towards taking STEM subjects. Some participants described how the 'textbook' type learning that is often associated with STEM subjects was detrimental to their willingness to continue with STEM beyond the compulsory stages of schooling, opting for more ‘hands on’ non-STEM subjects. Teachers are encouraged to be more aware of the influence that their teaching can have on students’ personal value of STEM. Schools are encouraged to engage their students in programs such as the Engineers Without Borders (EWB) Australia school outreach program which involves engineering and technical professionals visiting schools and running:

> creative, hands-on workshops designed to open young people’s minds to the challenges facing developing countries. They also highlight inspiring career options available to engineers and technical professionals and the power of humanitarian engineering to create positive change (Engineers Without Borders Australia, 2019, para. 3).

Activities such as the one highlighted above are likely to give students a sense of the societal value of STEM in an engaging ‘hands-on’ environment. Exposure to STEM outside of the classroom was also identified in participant interviews as influencing students’ attitudes towards STEM. Alana highlighted how her opportunity to conduct science experiments at home along with her brother ignited a passion and curiosity for STEM concepts from a young age. Role models in STEM are also shown to positively influence students’ attitudes towards STEM. Brodie described how discussions with his father (a STEM professional) and one of his colleagues further developed his interest in a STEM related field. Samuel also outlined the impact that conversation with family members working in STEM fields had on him by giving him a better understanding of the type of work that is conducted in those fields.

The societal value that students place on STEM may potentially alter their perceptions of the nature and usefulness of studying STEM subjects and following a STEM career pathway. Altruistic qualities were apparent in some participants with the desire to ‘help others’ indicated as a reason for further pursuing STEM. Wang and Degol (2017) suggested that many students may not fully understand the true nature of STEM and what the attainment of a STEM degree might mean. Teachers and career advisers should attempt to describe the altruistic nature of many STEM careers, should the focus be on improving female participation in STEM (Wang & Degol, 2017). A more comprehensive discussion of the wider benefit of STEM work and its contribution to the advancement of society as a whole should be attempted to respond to the altruistic qualities of many students, particularly females (Wang & Degol, 2017). A more extensive discussion of the variety of STEM majors and career options that are available within the field of STEM could improve students' understanding of the nature of STEM (Wang & Degol, 2017). Not only do students need to better understand the nature of STEM type work, but they should be given the opportunity to explore the types of jobs that a particular STEM degree might lead to and the educational pathway and related decisions that would likely lead them in that direction (Wang & Degol, 2017). STEM subject curriculum should include content that emphasises the contribution that STEM can make to improve the quality of people's lives. It is suggested that schools should:

- Engage teachers and course/career advisers in discussions with students and their families about the nature of and value of STEM education in their personal lives as well as the role that STEM plays in the wider community and society in general;
- Develop creative ways to make STEM education more accessible to students, particularly from rural, regional, remote and low-SES communities; and
- Develop partnerships with STEM industries, providing students with authentic STEM experiences and role models in STEM.

Heeding this advice would allow students to be involved in discussions with their peers, teachers, career advisors, STEM professionals and families about STEM careers. Students would then have the opportunity to familiarise themselves with the role of STEM in the advancement of society and the overall value of both STEM education and careers in STEM. Although many schools are adopting some of this advice to varying degrees, it is not always as explicit and targeted as it could be.

7.3. Limitations of the findings

A series of methodological limitations were outlined in Section 3.7. The discussion provided in this section described a number of limitations that arise from the use of secondary data. However, many of these limitations were counteracted by a number of strengths that were associated with the PISA and LSAY datasets that were used in the analyses during the quantitative phase of the research. The ability to access a dataset with a large number of participants who were sampled using a two-stage stratified sampling design with strict quality assurance policies allowed the researcher to be confident in the quality of data being analysed and allowed for the generalisation of results to the Australian cohort of students entering Year 12. A large number of variables relating to students' demographic background, attitudes towards science, ability in science and mathematics, subject enrolment and school related information made it possible to adequately address Research Question 1. It could also be argued that using PISA 2006 and LSAY Waves 1-4 (2006-2009) data limited in its applicability to the current cohort of Australian secondary students due to the number of years that have passed since data collection. The reason for choosing this particular dataset was its emphasis on attitudes towards science. A more recent PISA survey conducted in 2015 also focussed on attitudes towards science but the Year 12 enrolment information that is collected by LSAY was not available at the time of the study. An advantage of using PISA 2006 data is that a subsequent examination of the relationships between variables in the current study and variables relating to post school pathways, including vocational and tertiary education and occupational outcomes (aged 25), could be undertaken. Longitudinal research which examines students' demographic background, attitudes towards and achievement in science, subject choice and post-school pathways into further education and careers would provide a platform for enhancing our understanding of an important and complex transitional phase of a person's life.

Section 3.7. also outlined some of the methodological limitations that exist with the use qualitative data, including issues relating to subjectivity in the analysis of descriptive data and a limited ability to generalise findings due to sample size restrictions. These limitations were outweighed by the level of rich and in-depth information in the form of explanations that were provided by participants that allowed the researcher to gain a better and more nuanced understanding of a complex phenomenon, addressing Research Question 2. Even though the sample of participants who were interviewed as part of the qualitative phase of the research was not drawn from the quantitative sample group, the findings from both phases of the research were complementary and a synthesis of findings from both phases provided a more balanced understanding of the decision-making process of students entering Year 12.

7.4. Recommendations for future research

The findings presented in this research have highlighted a number of factors that influence students' decisions of whether to enrol in a STEM subject in Year 12. Potential explanations were provided in the discussion chapter (Chapter 6) that go some way to help explicate the ways in which these factors interact during the decision-making process, however a number of gaps in understanding still exist relating to the phenomenon of subject choice decision making and the declining enrolments in STEM education at all levels.

A major finding of this research was the effect of immigrant status on STEM subject choice, with native students being less likely to enrol in a STEM subject in Year 12 than those students from migrant backgrounds. A recent report used the binary immigrant status variable from PISA 2006 and subsequent LSAY waves (same used in this study) to investigate the post-school pathways of Australian students, including information relating to participation in higher education, vocational education and training (VET) and the labour market (Ranasinghe, Chew, Knight, & Siekmann, 2019). They found that students from migrant backgrounds (non-native) were more likely to follow a pathway into higher education and work and less likely to follow an alternative pathway compared with native students (Ranasinghe et al., 2019). However, no research has been located that describes the differences between the STEM enrolment patterns of native and non-native Australian students in Year 12.

This finding is one of the main contributions that the current research has provided to the literature on STEM enrolment. Further, the effect of immigrant status on STEM subject choice is mediated by attitudes towards science and achievement in science and mathematics. This finding is unique, particularly in the Australian context, and was discussed in detail in Section 6.5. However, it needs to be analysed further and explored in a more nuanced way. The binary categorisation of the immigrant status variable used in this research is perhaps too coarse and a variable that accounts for students (and their parents), separated by birth regions of the world, could offer more insight into the phenomena. Marjoribanks (2004, 2005, 2006) has shown stark differences between cultural and ethnic groups in relation to achievement and educational aspirations. A more fine-grained analysis is needed in the Australian context, with special consideration given to the make-up of the Australian population and the types of migrants that are present within the population. The Australian skilled migration program has been a significant factor in the continually evolving nature of Australian society since the mid-1990s (Saunders, 2008). This particular scheme has affected the status of people who are migrating to the country, with a strong representation of migrant parents with professional occupations (Saunders, 2008). Since the educational level and occupation of parents has been shown to influence the educational aspirations of children (Croll, 2008; Vidal Rodeiro, 2007), it is logical to hypothesise that a migrant population with a high representation in professional occupations may have children who are more likely to also develop aspirations for professional occupations. Evidence for this effect was provided in the qualitative phase of the research, particularly with the excerpts provided by Arun and Keira, showing the effect of parental influence on children from migrant backgrounds. However, further research is needed to explore questions related to these areas, e.g. What are the differences in STEM aspirations among students by cultural and ethnic groups represented in the Australian population, taking into account parental occupation and education? How do parental aspirations and expectations for their children account for these differences in students' STEM aspirations?

Findings from the quantitative and qualitative phases of the research showed that the value students place on STEM ultimately influences the likelihood of them enrolling in a STEM subject in Year 12. The value students place on STEM is affected by the 'Nature of STEM' and the way it is taught in school. Many potential explanations have been provided which attempt to describe how attitudes towards STEM are developed, but it is difficult to pinpoint particular features of STEM classrooms that have the greatest influence over the decision-making process of students. Teacher quality, support, subject content and the typical nature of classroom activities (STEM pedagogy) have been discussed as influential in-class factors that affect attitude development in STEM (see a discussion of these influences in Section 6.9). In Australia, many Year 12 STEM subjects have lengthy externally assessed examinations at the conclusion of the school year. These types of examinations are usually associated with high levels of student anxiety, stress and perceived difficulty of the subject as indicated by Arun when discussing his reasons for not enrolling in both Specialist

Mathematics and Mathematical Methods (see Section 5.4.7.). The increased workload that Arun perceived to be associated with two high-level STEM subjects with examinations led to his decision to no longer continue with these subjects beyond Year 11. Students considering a STEM career pathway typically enrol in these types of STEM subjects in Year 11 before deciding whether to continue with them for Year 12. Schools often have Year 11 students sit examinations at the end of each semester in an environment similar to that of the Year 12 examinations in order to prepare them for the type of environment they will encounter should they continue with these subjects. It could be hypothesised that these experiences with examinations for STEM subjects at Year 11, and the anxiety and pressure that ensue, have a negative effect on their likelihood of subsequent enrolment in Year 12 and future STEM engagement beyond formal schooling. Research could be developed that investigates the effects of STEM subjects having externally assessed examinations on the likelihood of enrolment in those subjects at Year 12.

In Section 6.10. various contextual school level variables including school size and subsequent enrolment numbers, inability to recruit and retain STEM-trained teachers, and timetable restrictions were shown to influence the actual level of control that students had over their subject choice decisions. In particular, results from the quantitative phase of the research (see Figure 4-4) highlighted that school location moderates the relationship between gender and STEM subject choice in Year 12. These findings suggest that female students' likelihood of enrolling in STEM is increased when they belong to a rural school compared with a metropolitan school. Conversely, male students from rural schools are less likely to enrol in STEM compared with male students in metropolitan schools. How can this effect be explained? It is recommended that future research poses this question and explores the interrelationships between gender, school location and STEM subject choice in a more nuanced and fine grained way.

The quantitative phase of this research utilised secondary data from PISA/LSAY 2006 to investigate the relationships between demographic backgrounds, attitudes towards science, achievement in science and mathematics, various school factors, and STEM subject choice in Year 12. The use of multilevel SEM enabled an investigation into the issues of Year 12 STEM subject choice in a way that reflects the complexity of the situation. A combination of background characteristics and mediating attitudinal and achievement variables on the student level were modelled whilst accounting for moderating effects of school level factors on student level relationships. Although enrolment in STEM at Year 12 is argued to be the critical point (particularly in South Australia) at which students decide whether to pursue a STEM pathway beyond formal schooling and into STEM careers, other periods of time throughout their educational journey could be investigated to get a more nuanced picture of the complex phenomenon of educational choice. As was outlined in the previous section, post school pathways could also be examined by extending the current models presented in this research to include information relating to enrolment in STEM degrees at university and careers in STEM at age 25. An extension of the SEM presented in the current research to include these variables would allow researchers to determine the predictive potency of the preceding variables. This would produce an intricate thread from demographic background to attitudes and achievement at age 15, through Year 12 enrolment, into tertiary enrolment patterns, and finally career outcomes. This type of model along with the current proposed model could also be partially replicated with more up-to-date data sets once they are released (i.e. PISA/LSAY 2015). Since PISA/LSAY 2006 only focussed on attitudes towards science, the models presented in this research could be replicated using PISA/LSAY 2003 and PISA/LSAY 2012, replacing attitudes towards science with attitudes towards mathematics. Similar models could be tested using these datasets.

A review of the literature highlighted the potential usefulness of the TPB to investigate the subject choice behaviour of students entering Year 12. Previous studies utilising the TPB were examined and the applicability of TPB to the current research topic was undertaken. The TPB was deemed to be an appropriate framework to guide the current study. The methodology that was developed and the ensuing data collection, analyses and discussion of results were all framed within the parameters of the TPB. However, the hierarchical nature of PISA/LSAY data used in the quantitative phase of the research, due to students being nested within schools, meant that the TPB had to be adapted to consider school related factors at a different level to student related factors. The TPB and previous adaptions of the model have typically only been used to undertake single level analyses. The results of this research have highlighted the value of considering the moderation effects of school variables

(Level 2) on the relationships between student variables (Level 1). The implications for this were described in detail in Section 6.2. Future researchers who are using data that is nested and who wish to use the TPB as the guiding conceptual framework are recommended to consider adapting the model to include multilevel analyses to reflect the hierarchical nature of the population of interest. The use of both multilevel multiple regression modelling and multilevel SEM in this research has shown the value of this type of analysis for nested data. Simple analyses of PISA/LSAY data would not have provided the opportunity to develop the same level of understanding of the complex phenomenon under examination.

7.5. Concluding remarks

A review of the literature surrounding enrolment in STEM education at various levels highlighted a research gap that needed to be investigated. A STEM skills shortage was being reported worldwide and the worrying flow-on effect this was likely to have for the economic prosperity of many countries was outlined. Hard evidence for the reported shortage was not always provided in reports. However, the advantage of having a graduating student cohort and society well versed in skills such as critical and creative thinking and advanced problem solving that are often developed through STEM education was clear. Much of the previous international research that was identified in the literature search focussed on individual STEM subjects rather than STEM as a whole. In particular, research that focussed on Year 12 STEM subject choice in South Australia was not located. It was hypothesised that a crucial time (particularly in South Australia) in the pathway from an individual's school experience and the transition to post school education and employment is choosing subjects for Year 12. This is the first time that students are relatively uninhibited by the compulsory requirements of curriculum authorities and are free to choose whichever subjects they desire, although this choice is limited by school offerings. The subjects they choose in this phase of schooling are likely to reflect their intended post-school educational and occupational pathways. Gaining an understanding of the factors that influenced students' STEM enrolment decisions in Year 12 and how these factors interacted was the goal of the current research.

Findings from the quantitative and qualitative phases of the research highlighted a number of factors that influenced the STEM decision-making process of students entering Year 12. Disparities existed between students from varying demographic backgrounds, with differences shown by gender (male students more likely to enrol), SES (high-SES students more likely to enrol) and immigrant status (non-native students more likely to enrol). Once multilevel modelling and interview responses were considered, a more nuanced and complex picture began to emerge. Many attitudinal, achievement, subjective norms (parents, peers and teachers), perceived behavioural control and intention related factors were shown to mediate the relationship between demographic background and STEM subject choice in Year 12. Various school related factors such as school type, school context and teacher quality were shown to moderate some of these interacting relationships on the student level. The relationship between students' attitudes, achievement, aspirations and post-compulsory subject choice was discussed in the results and discussion chapter of the thesis. In reviewing these findings, a number of recommendations were provided.

STEM education is valuable on an individual level as a result of the development of skills in problem solving and critical and creative thinking (Education Council, 2015). It could be argued that increasing enrolments in STEM education is valuable for society as a whole due to the need to upskill the future workforce. However, should this be the point of emphasis? I argue that the focus of schools in helping to shape students' decisions of which subjects to enrol in before entering the post-compulsory phase of education should be based on what options are best for the pathway the students wish to pursue. These aspirational pathways should also be carefully sculpted through students developing a complex understanding of the factors that may influence their decision-making process. If students are empowered to make thoughtful and targeted decisions that affect their future then society will certainly benefit from people pursuing professions about which they are passionate. If education systems and schools are able to make changes to the way STEM is taught and if teachers are suitably qualified and supported to enhance their pedagogy in STEM learning experiences then students are likely to develop more positive attitudes towards STEM, develop STEM career aspirations and subsequently be more likely to choose STEM subjects in Year 12.

8. APPENDICES

Appendix 1

Thank you for agreeing to fill out this form. The project aims to understand how students in South Australia choose whether or not to enrol in STEM subjects in Year 12. If we ask you to participate in an interview we are going to discuss a range of aspects relating to your decision making process when choosing Year 12 subjects to undertake. We are interested in positive, negative and neutral views about different potential influencing factors.

Could you please fill out the following?

1. Name:
2. What is your gender?

   Male ☐ Female ☐

   Other

3. Were you born in Australia? Yes ☐ No ☐
   - If not, where were you born?
4. Was your father born in Australia? Yes ☐ No ☐
   - If not, where was he born?
5. Was your Mother born in Australia? Yes ☐ No ☐
   - If not, where was she born?

In this section you will be asked some questions about your family and your home. Some of the following questions are about your mother and father or those person(s) who are like a mother or father to you — for example, guardians, step-parents, foster parents, etc. If you share your time with more than one set of parents or guardians, please answer the following questions for those parents/guardians you spend the most time with.

6. What is your mother's main job?
   (e.g. school teacher, kitchen-hand, sales manager)
   (If she is not working right now, write her last main job)
7. What is your father's main job?
   (e.g. school teacher, kitchen-hand, sales manager)
   (If he is not working right now, write his last main job)
8. What is the highest level of education your mother completed? (Please tick one)

☐	Did not complete primary school
☐	Completed primary school

☐	Completed some secondary school but not more than Year 10
☐	Completed Year 10 or 11 and then did a TAFE certificate (e.g. hairdressing, bricklayer)
☐	Completed Year 12
☐	Completed Year 12 plus a TAFE certificate (e.g. hairdressing, bricklayer)
☐	Completed Year 12 plus a TAFE diploma (e.g. IT, Vet nursing)
☐	Completed Year 12 plus a university degree

9. What is the highest level of education your father completed? (Please tick one)

☐	Did not complete primary school
☐	Completed primary school
☐	Completed some secondary school but not more than Year 10
☐	Completed Year 10 or 11 and then did a TAFE certificate (e.g. hairdressing, bricklayer)
☐	Completed Year 12
☐	Completed Year 12 plus a TAFE certificate (e.g. hairdressing, bricklayer)
☐	Completed Year 12 plus a TAFE diploma (e.g. IT, Vet nursing)
☐	Completed Year 12 plus a university degree

10. Did you undertake any of the following STEM subjects in Year 11?
    - If yes, what grade did you receive for each?

		Grade (e.g. A, B, C, D or E)
☐	Agricultural and Horticultural Science	
☐	Biology	
☐	Chemistry	
☐	Geology	
☐	Nutrition	
☐	Physics	
☐	Psychology	
☐	Scientific Studies	
☐	Information Technology	
☐	Mathematical Methods	

☐	Specialist Mathematics	
☐	**None of These**	

11. Are you planning to undertake/undertaking any of the following STEM subjects during Year 12?

☐	Agricultural and Horticultural Science
☐	Biology
☐	Chemistry
☐	Geology
☐	Nutrition
☐	Physics
☐	Psychology
☐	Scientific Studies
☐	Information Technology
☐	Mathematical Methods
☐	Specialist Mathematics
☐	**None of These**

Appendix 2

School student interview – STEM subject choice in Year 12

Hi ……….

Thank you for agreeing to participate in a one-to-one interview which aims to understand how students in South Australia choose whether or not to enrol in STEM subjects in Year 12. We are going to discuss a range of aspects relating to your decision-making process when choosing Year 12 subjects to undertake. This interview is of an open-ended nature so you are welcome to raise any issues or concerns relating to the project. There are no wrong answers rather a point of view. Feel free to share your thoughts openly and freely. We are interested in positive, negative and neutral views about different potential influencing factors.

I remind you that the microphone will be recording our conversation. However, any identifying conversation will be removed from subsequent data handling and deleted in reports.

You are reminded that you are free to cease participation and remove yourself from the project at any point with no repercussions. This will have no bearing on services provided to you or your results in class.

Open – How initial questions related to key concepts will be asked

Direct – Some more direct questions to have as a reminder of areas that may need to be pursued

Interview Questions

1. How did you come to the decision to choose your subjects for Year 12?
2. What would you say was the biggest influence on your subject choices?
3. Why did you choose/not choose a STEM subject(s)?
4. Going in to your subject selection meeting, did you select the subjects for Year 12 that you originally intended to?
    a. If not, why?
5. What was your average grade in Maths, Science and IT in Year 10?
    a. Did your previous results influence your decision to enrol in STEM at Year 12?
6. Do you enjoy studying STEM subjects?
    a) If so, what about them do you enjoy? If not, what don't you enjoy?
7. How valuable is STEM in society?
    a) Why? Why not?
8. Do you find STEM to be valuable in your personal everyday life?
    a) Why? Why not?
9. Do you see yourself as someone who could study STEM further?
    a) Why? Why not?
10. What are you hoping to do after Year 12?
    a) Do you need to study a STEM subject in Year 12 in order to follow that career path?
        i. Why?
11. What opportunities have you been given to explore STEM outside of the classroom?
    a. Have you explored the region and investigated how STEM is applied in the context of the local area?
        i. If so, how was it beneficial? Did it influence your decision to continue with STEM?
        ii. If not, did that influence your decision to continue with STEM?
12. Do you feel that the decision to enrol/not enrol in a STEM subject/s was entirely your decision?

a. If not, why?

b. If not, who influenced that decision?

13. What do you think of your previous teachers in STEM subjects?
    a) Do you think they have influenced your decision to choose/not choose STEM subject/s in Year 12?
        i. If so, how?
    b) Did any of your teachers encourage you to enrol in a STEM subject/s?
    c) Did any of your teachers discourage you from enrolling in a STEM subject/s?
14. Are any of your friends undertaking STEM subjects in Year 12?
    a) Have they had any influence over your decision to choose/not choose STEM subject/s?
    b) Did any of your friends tell you to enrol in a STEM subject?
    c) Did any of your friends tell you not to enrol in a STEM subject?
15. Do your parents/caregivers work in a STEM job?
    a) If so, what is their job?
    b) Have they had any influence over you decision to choose/not choose STEM subject/s?
        i. If so, how?
    c) Did your parents/caregivers encourage you to enrol in a STEM subject?
    d) Did your parents/caregivers encourage you not to enrol in a STEM subject?
16. Has your school had any influence over your decision to study/not study a STEM subject/s?
    a) If so, how?
17. Does your school offer the subjects that you wish to study?
    a) Has this affected you Year 12 STEM subject choice?
18. Were there any external influences over your decision?
19. Do you know anyone else that works in a STEM career?
    c. If so, what do they do and have they influenced your decision to choose/not choose STEM subject/s?

Thank you for taking the time to participate in this one-to-one interview.

Appendix 3

Professor Lindsey Conner
Dean (People and Resources)
College of Education, Psychology and Social Work
Flinders University
Education Building
GPO Box 2100
Adelaide SA 5001
lindsey.conner@flinders.edu.au
Ph: 8201 3532
CRICOS Provider No. 00114A

04/07/2017

LETTER OF INTRODUCTION
Principal/Teacher

Dear Sir/Madam,

This letter is to introduce David Jeffries who is a PhD student in the College of Education, Psychology and Social Work at Flinders University. He will produce his student card, which carries a photograph, as proof of identity.

He is undertaking research leading to the production of a thesis or other publications on the subject of "Factors that influence STEM subject choice in Year 12". STEM stands for Science, Technology, Engineering and Mathematics.

He would like to invite you to assist in this project in two ways. First, by granting access to interview Year 11 students on certain aspects of this topic. No more than 50 minutes on one occasion would be required. Interviews will be conducted in a highly visible space within the school that the student is familiar and comfortable with. Second, by Year 11 home/care group teachers helping to assist with coordination of the research. This would involve the teachers handing out an information pack to students, conducting a short survey/screening tool in class and collecting parent/caregiver consent forms.

Be assured that any information provided will be treated in the strictest confidence and none of the participants will be individually identifiable in the resulting thesis, report or other publications. They are, of course, entirely free to discontinue their participation at any time or to decline to answer particular questions.

Since he intends to make a tape recording of the interview, he will seek their consent to record the interview, to use the recording or a transcription in preparing the thesis, report or other publications, on condition that their name or identity is not revealed. The recording will not be made available to other persons, although de-identified transcripts may be made available. It may be necessary to make the recording available to secretarial assistants (or a transcription service) for transcription, in which case they may be assured that such persons will be asked to sign a confidentiality agreement which outlines the requirement that their name or identity not be revealed and that the confidentiality of the material is respected and maintained.

Any enquiries you may have concerning this project should be directed to me at the address given above or by phone 0421 007 332 or by e-mail lindsey.conner@flinders.edu.au.

Thank you for your attention and assistance.

Yours sincerely

Prof Lindsey Conner

Principal Supervisor

College of Education, Psychology and Social Work

Flinders University

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7762). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Professor Lindsey Conner
Dean (People and Resources)
College of Education, Psychology and Social Work
Flinders University
Education Building
GPO Box 2100
Adelaide SA 5001
lindsey.conner@flinders.edu.au
Ph: 8201 3532
CRICOS Provider No. 00114A

04/07/2017

LETTER OF INTRODUCTION
Parents/Caregivers

Dear Parent/Caregiver,

This letter is to introduce David Jeffries who is a PhD student in the College of Education, Psychology and Social Work at Flinders University. He will produce his student card, which carries a photograph, as proof of identity.

He is undertaking research leading to the production of a thesis or other publications on the subject of "Factors that influence STEM subject choice in Year 12". STEM stands for Science, Technology, Engineering and Mathematics.

He would like to invite your child to assist with this project by agreeing to participate in an interview which covers certain aspects of this topic. No more than 50 minutes on one occasion would be required. Interviews will be conducted in a highly visible space within the school that they are familiar and comfortable with.

Be assured that any information provided will be treated in the strictest confidence and they will not be individually identifiable in the resulting thesis, report or other publications. They are, of course, entirely free to discontinue their participation at any time or to decline to answer particular questions.

Since he intends to make a tape recording of the interview, he will seek your consent, on the attached form, to record the interview, to use the recording or a transcription in preparing the thesis, report or other publications, on condition that their name or identity is not revealed. The recording will not be made available to any other person. It may be necessary to make the recording available to secretarial assistants (or a transcription service) for transcription, in which case you may be assured that such persons will be required to sign a confidentiality agreement which outlines the requirement that their name or identity not be revealed and that the confidentiality of the material is respected and maintained.

Any enquiries you may have concerning this project should be directed to me at the address given above or by phone 0421 007 332 or by e-mail lindsey.conner@flinders.edu.au.

Thank you for your attention and assistance.

Yours sincerely,

Prof Lindsey Conner

Principal Supervisor

College of Education, Psychology and Social Work

Flinders University

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inspiring achievement

Professor Lindsey Conner
Dean (People and Resources)
College of Education, Psychology and Social Work
Flinders University
Education Building
GPO Box 2100
Adelaide SA 5001
lindsey.conner@flinders.edu.au
Ph: 8201 3532
CRICOS Provider No. 00114A

INFORMATION SHEET
Principal/Teacher

Title: 'Factors that influence STEM subject choice in Year 12'

Researcher:
Mr David Jeffries
College of Education, Psychology and Social Work
Flinders University
Ph: 8201 5584

Supervisor(s):

Prof Lindsey Conner
College of Education, Psychology and Social Work
Flinders University
Ph: 8201 3532

Adj Assoc Prof David Curtis
College of Education, Psychology and Social Work
Flinders University
E: david.curtis@flinders.edu.au

Description of the study:
This study is part of the project entitled 'Factors that influence STEM subject choice in Year 12'. STEM stands for Science, Technology, Engineering and Mathematics. This project will investigate factors that influence students' decisions of whether to enrol in a Year 12 STEM subject or not. This project is supported by the College of Education, Psychology and Social Work at Flinders University.

Purpose of the study:
This project aims to:

- Identify factors that influence students' STEM enrolment decisions in Year 12
- Understand how the influencing factors affect STEM enrolment decisions
- Understand why the influencing factors have such a large impact on STEM enrolment decisions

What will students be asked to do?
Students will be asked to complete a short questionnaire. From this they may be asked to participate in a one-to-one interview. If they wish to express a willingness to participate further they will be invited to attend a one-to-one interview with a researcher who will ask them questions

about their views about factors that influence their decision making in relation to STEM subject choice. Participation is entirely voluntary. The interview will take about 50 minutes (one lesson period). Interviews will be conducted in a highly visible space within the school that they are familiar and comfortable with. The interview will be recorded using a digital voice recorder. Once recorded, the interview will be transcribed (typed-up) and stored as a computer file. Once transcribed, the recording will be destroyed.

What benefit will students gain from being involved in this study?
Students may not personally benefit from their involvement in this study. However, the sharing of their experiences will assist in the improvement of the planning and delivery of future educational and career counselling for subsequent students. This project will also help them to gain an understanding of how they think and make important decisions about their studies.

Will students be identifiable by being involved in this study?
We do not need students' names and they will be anonymous. The interview will be typed-up and saved as a file with any identifying information removed. However, the audio recording will be stored on a protected file within the university repository for 7 years in accordance with university ethics guidelines. The typed-up file will be stored on a password protected computer that only the Principal Researcher, David Jeffries will have access to. Students will be allocated pseudonyms in the transcripts and in publications that arise from the study so they will not be individually identifiable and their comments will not be linked directly to them.

Are there any risks or discomforts if students are involved?
The researcher anticipates no risks from their involvement in this study; however, given the nature of the project some participants could experience emotional discomfort. Participants will share their thoughts and perceptions on the factors that influence their decisions in relation to STEM subject choice. Participants may be identified by other students if they wish to discuss involvement with peers, but all subsequent analyses and release of results will ensure confidentiality and anonymity. If any emotional discomfort is experienced, please contact Kids Helpline on 1800 55 1800 for support / counselling that may be accessed free of charge by all participants. If you have any concerns regarding anticipated or actual risks or discomforts, please raise them with the researcher.

How do students agree to participate?
An information pack which contains a letter of introduction, information sheet, brief questionnaire (screening tool) and consent form will be given to all potential participants. They will be asked to discuss the project and their potential involvement with parents/caregivers. If they agree to participate parents/caregivers will be asked to read and sign the consent form, along with the student's signature and get them to return it to their class teacher. Participation is voluntary. They may answer 'no comment' or refuse to answer any questions and they are free to withdraw from the interview at any time without effect or consequences.

How will students receive feedback?
On project completion, outcomes of the project will be provided to all participating schools.

Thank you for taking the time to read this information sheet and we hope that you will accept our invitation for your students to be involved.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7762). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

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Ph: 8201 3532
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INFORMATION SHEET
Parents/Caregivers/Students

Title: 'Factors that influence STEM subject choice in Year 12'

Researcher:
Mr David Jeffries
College of Education, Psychology and Social Work
Flinders University
Ph: 8201 5584

Supervisor(s):

Prof Lindsey Conner
College of Education, Psychology and Social Work
Flinders University
Ph: 8201 3532

Adj Assoc Prof David Curtis
College of Education, Psychology and Social Work
Flinders University
E: david.curtis@flinders.edu.au

Description of the study:
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Purpose of the study:
This project aims to:

- Identify factors that influence students' STEM enrolment decisions in Year 12
- Understand how the influencing factors affect STEM enrolment decisions
- Understand why the influencing factors have such a large impact on STEM enrolment decisions

What will your child be asked to do?
Year 11 students are invited to complete a brief questionnaire in class and to attend a one-on-one interview with a researcher who will ask them questions about their views about factors that influence their decision making in relation to STEM subject choice. Various individual areas of

inspiring achievement

interest relating to demographic background, attitudes towards STEM, aspirations for STEM and achievement in Maths and Science. Questions will also be asked relating to school factors such as school type/location/size, teacher influence and peer influence. Participation is entirely voluntary. The interview will take about 50 minutes. Interviews will be conducted in a highly visible space within the school that they are familiar and comfortable with. The interview will be recorded using a digital voice recorder to help with analysing the results. Once recorded, the interview will be transcribed (typed-up) and stored as a computer file and the recording will be destroyed

What benefit will my child gain from being involved in this study?
Individual students will not benefit directly from their participation in this study. However, the sharing of their experiences will assist in the improvement of the planning and delivery of future educational and career counselling. This project will also help them to gain an understanding of how they think and make important decisions. We are very keen to deliver a service and resources which are as useful as possible to future students.

Will my child be identifiable by being involved in this study?
We do not need their name and they will be anonymous. The interview will be typed-up and saved as a file with any identifying information removed. However, the audio recording will be stored on a protected file within the university repository for 7 years in accordance with university ethics guidelines. The typed-up file will be stored on a password protected computer that only the Principal Researcher, David Jeffries will have access to. Students will be allocated pseudonyms in the transcripts and in publications that arise from the study so they will not be individually identifiable and their comments will not be linked directly to them.

Are there any risks or discomforts if my child is involved?
The researcher anticipates no risks from their involvement in this study; however, given the nature of the project some participants could experience emotional discomfort. Participants will share their thoughts and perceptions on the factors that influence their decisions in relation to STEM subject choice. Participants may be identified by other students if they wish to discuss involvement with peers, but all subsequent analyses and release of results will ensure confidentiality and anonymity. If any emotional discomfort is experienced, please contact Kids Helpline on 1800 55 1800 for support / counselling that may be accessed free of charge by all participants. If you have any concerns regarding anticipated or actual risks or discomforts, please raise them with the researcher.

How does my child agree to participate?
A consent form accompanies this information sheet. Please discuss the project and your child's potential involvement with them. If they agree to participate please read and sign the form, along with their signature and get them to return it to their class teacher. Participation is voluntary. They may answer 'no comment' or refuse to answer any questions and they are free to withdraw from the interview at any time without effect or consequences.

How will my child receive feedback?
On project completion, outcomes of the project will be provided to participating schools.

Thank you for taking the time to read this information sheet and we hope that you will accept our invitation for your child to be involved.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 7762). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Example of Consent from a Principal

Principal Email

Dear [Principal],

My name is David Jeffries and I am a PhD student from the College of Education, Psychology and Social Work at Flinders University. I am undertaking a project entitled “Factors that influence STEM subject choice in Year 12”. The project seeks to find out what factors influence the Year 12 STEM enrolment decisions of students in South Australian schools. It will attempt to understand how these factors influence their enrolment choices and why they have such an influence. Data collected in this project will potentially lead to publications. All Year 11 Students would be asked to fill out a brief questionnaire in class and a few students would be asked to participate in a one-to-one interview. All details of the project and what is involved for your students are outlined in the letter of introduction and information sheet attached. Approximately 50 minutes will be needed on one occasion for the interview. Interviews will be conducted in a room within the school during class time, study periods or breaks depending on the student’s availability.

Responses given in interviews will be audio recorded for later transcription. Consent for this recording will be sought on a consent form that a parent/caregiver and the student will need to sign. Neither the students’ nor the school will be identifiable. A summary of results will be provided to the school at the conclusion of the study.

If you agree to your school participating in this study, please email back with confirmation of your consent. Also, please forward this email with attachments to all Year 11 home/care group teachers.

Thank you for taking the time to listen.

School Response Example

Hi David

[Anonymised] High School agrees to this research being conducted.

I have forwarded the information to [First Last] – Senior School AP (first.last123@schools.sa.edu.au) to obtain consent and [First Last] (first.last456@schools.sa.edu.au) will be collecting the responses.

If you require any further information please contact me.

Flinders
UNIVERSITY

PARENTAL CONSENT FORM FOR CHILD PARTICIPATION IN RESEARCH

By Interview

Factors that influence STEM subject choice in Year 12

I ……………………………………………………………………………………………

being over the age of 18 years hereby consent to my child ……………………………………

participating, as requested, in the interview for the research project on STEM subject choice.

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to audio recording of my child's information and participation.
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
   - My child may not directly benefit from taking part in this research.
   - My child is free to withdraw from the project at any time and is free to decline to answer particular questions.
   - While the information gained in this study will be published as explained, my child will not be identified, and individual information will remain confidential.
   - Whether my child participates or not, or withdraws after participating, will have no effect on any treatment or service that is being provided to him/her.
   - Whether my child participates or not, or withdraws after participating, will have no effect on his/her progress in his/her course of study, or results gained.
   - My child may ask that the recording be stopped at any time, and he/she may withdraw at any time from the session or the research without disadvantage.
6. I **agree/do not agree*** to the **tape/transcript*** being made available to other researchers who are not members of this research team, but who are judged by the research team to be doing related research, on condition that my identity is not revealed.

Participant's signature…………………………………………**Date**……………………

Parent/Caregiver's signature…………………………………**Date**……………………

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name………………………………………………………………………………

Researcher's signature…………………………………………**Date**……………………

SBREC FINAL APPROVAL NOTICE

Project No.:	**7762**
Project Title:	Factors that influence STEM subject choice in Year 12
Principal Researcher:	Mr David Jeffries
Email:	jeff0119@flinders.edu.au

Approval Date:	26 September 2017	Ethics Approval Expiry Date:	**31 December 2021**

The above proposed project has been **approved** on the basis of the information contained in the application, its attachments and the information subsequently provided with the addition of the following comment(s):

Additional information required following commencement of research:

Permissions
Please ensure that copies of the correspondence granting permission to conduct the research from (a) all individual AISSA schools and Catholic Education of South Australia (CESA) are submitted to the Committee *on receipt.* Please ensure that the SBREC project number is included in the subject line of any permission emails forwarded to the Committee. Please note that data collection should not commence until the researcher has received the relevant permissions (item D8 and Conditional approval response – number 11).

RESPONSIBILITIES OF RESEARCHERS AND SPERVISORS

1. Participant Documentation

Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

- all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.
- the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain

international dialling codes for all telephone and fax numbers listed for all research to be conducted overseas.

- the SBREC contact details, listed below, are included in the footer of all letters of introduction and information sheets.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project Number 'INSERT PROJECT No. here following approval'). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au.

2. Annual Progress / Final Reports

In order to comply with the monitoring requirements of the *National Statement on Ethical Conduct in Human Research (March 2007)* an annual progress report must be submitted each year on the **26 September** (approval anniversary date) for the duration of the ethics approval using the report template available from the Managing Your Ethics Approval SBREC web page. *Please retain this notice for reference when completing annual progress or final reports.*

If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please submit either (1) a final report; or (2) an extension of time request and an annual report.

Student Projects

The SBREC recommends that current ethics approval is maintained until a student's thesis has been submitted, reviewed and approved. This is to protect the student in the event that reviewers recommend some changes that may include the collection of additional participant data.

Your first report is due on **26 September 2018** or on completion of the project, whichever is the earliest.

3. Modifications to Project

Modifications to the project must not proceed until approval has been obtained from the Ethics Committee. Such proposed changes / modifications include:

- change of project title;
- change to research team (e.g., additions, removals, principal researcher or supervisor change);
- changes to research objectives;
- changes to research protocol;
- changes to participant recruitment methods;
- changes / additions to source(s) of participants;
- changes of procedures used to seek informed consent;
- changes to reimbursements provided to participants;
- changes / additions to information and/or documentation to be provided to potential participants;
- changes to research tools (e.g., questionnaire, interview questions, focus group questions);
- extensions of time.

To notify the Committee of any proposed modifications to the project please complete and submit the *Modification Request Form* which is available from the Managing Your Ethics Approval SBREC web page. Download the form from the website every time a new modification request is submitted to ensure that the most recent form is used. Please note that extension of time requests should be submitted prior to the Ethics Approval Expiry Date listed on this notice.

Change of Contact Details

Please ensure that you notify the Committee if either your mailing or email address changes to ensure that correspondence relating to this project can be sent to you. A modification request is not required to change your contact details.

4. Adverse Events and/or Complaints

Researchers should advise the Executive Officer of the Ethics Committee on 08 8201-3116 or human.researchethics@flinders.edu.au immediately if:

- any complaints regarding the research are received;
- a serious or unexpected adverse event occurs that effects participants;
- an unforeseen event occurs that may affect the ethical acceptability of the project.

Kind regards

Andrea

Mrs Andrea Fiegert and Ms Rae Tyler
Ethics Officers and Executive Officer, Social and Behavioural Research Ethics Committee
Andrea - Telephone: +61 8 8201-3116 | Monday, Tuesday and Wednesday
Rae – Telephone: +61 8 8201-7938 | Tuesday, Thursday and Friday

Email: human.researchethics@flinders.edu.au
Web: Social and Behavioural Research Ethics Committee (SBREC)

Manager, Research Ethics and Integrity – Dr Peter Wigley
Telephone: +61 8 8201-5466 | email: peter.wigley@flinders.edu.au
Research Services Office |Union Building Basement
Flinders University
Sturt Road, Bedford Park | South Australia | 5042
GPO Box 2100 | Adelaide SA 5001

Government of South Australia
Department for Education and Child Development

System Performance

Level 8
31 Flinders Street
Adelaide SA 5000
GPO Box 1152
Adelaide SA 5001
DX 541
Tel: 8226 0809
Fax: 8226 1605

DECD CS/17/000750-1.3

Mr David Jeffries
Flinders University
College of Education, Psychology and Social Work
Room 3.11b Education Building
GPO Box 2100
ADELAIDE SA 5001

Dear Mr Jeffries

Your research project "*Factors that influence STEM subject choice in Year 12*" has been reviewed by a senior officer within our department.

I am pleased to advise you that your application has been approved, subject to the following conditions:

- That a copy of any final reports, presentations or manuscripts accepted for publication be submitted to the DECD.ResearchUnit@sa.gov.au mailbox 30 days prior to their publication.

Please contact Betty Curzons in the Business Intelligence Unit for any other matters you may wish to discuss regarding your application (Tel. (08) 8226 0809 or email: DECD.ResearchUnit@sa.gov.au).

I wish you well with your research.

B.T.

Ben Temperly
EXECUTIVE DIRECTOR, SYSTEM PERFORMANCE

27 **July 2017**

catholic education south australia

Adelaide Catholic Education Centre
116 George Street, Thebarton SA 5031
PO Box 179, Torrensville Plaza SA 5031
T +61 8 8301 6600 **F** +61 8 8301 6611
E director@cesa.catholic.edu.au
W www.cesa.catholic.edu.au

David Jeffries
Email: david.jeffries@flinders.edu.au

Dear David

RE Factors that influence STEM subject choice in Year 12.

Thank you for your email of 22 August 2017 in which you seek permission to conduct research in South Australian Catholic schools. As you are aware, your application was unable to progress until a copy of ethics approval from your university was received. I am pleased to advise that we received this approval from you on the 26 August and your research proposal is now approved subject to the following conditions:

- permission of the principal of the school is required
- individual students, schools and the Catholic sector itself is not specifically identified in published research data and conclusions
- the permission of parents of each child involved in the study and the participating teachers has been obtained
- the research complies with the ethics proposal of the ethics committee
- the research complies with any provisions under the Privacy Act that may require adherence by you as researcher in gathering and reporting data
- the presentation in the school is carried out within view of the classroom teacher or authorised school observer
- no comparison between schooling sectors is made
- sector requirements relating to child protection and police checks are met by researchers:
  - where researchers obtain information in relation to a student which suggests or indicates abuse, this information must be immediately conveyed to the Director of Catholic Education SA
  - all researchers and assistants, who in the course of the research interact in any way with students, are required to provide evidence of a clearance letter issued by the Catholic Archdiocese of Adelaide Police Check Unit (ph:08 8210 8287) or another form of acceptable police clearance.

At the conclusion of the study a copy of the research findings should be forwarded to:
Director
Catholic Education Office
PO Box 179
TORRENSVILLE PLAZA SA 5031 or
director@cesa.catholic.edu.au

Please accept my very best wishes for the research process.

Yours sincerely

M H Conway

MONICA CONWAY
ASSISTANT DIRECTOR

38 September 2017

REF: 201721

Appendix 4

Direct and indirect effects on STEM subject choice (Unstandardised) (Pooled)

	Direct Effects				Indirect Effects				Total Effects			
	B	SE B	Z	p	B	SE B	Z	p	B	SE B	Z	p
Female - STEMSub	-0.101	0.039	-2.594	0.009								
Female - AchSciMat - STEMSub					-0.031	0.011	-2.776	0.006				
Female - EnjoySc - AchSciMat - STEMSub					-0.015	0.003	-5.090	0.000				
Female - SlfConSc - AchSciMat - STEMSub					-0.024	0.003	-7.305	0.000				
Female - PerValSc - STEMSub					-0.022	0.005	-4.053	0.000				
Female - EnjoySc - STEMSub					-0.019	0.006	-3.093	0.002				
Female - SlfConSc - STEMSub					-0.015	0.007	-2.163	0.031				
Sum of Indirect Effects (Female to STEMSub)					-0.125	0.018	-7.004	0.008				
Sum of Direct and Indirect Effects (Female to STEMSub)									-0.226	0.041	-5.540	0.000
SES - STEMSub	0.015	0.025	0.584	0.559								
SES - AchSciMat - STEMSub					0.107	0.010	10.609	0.000				
SES - EnjoySc - AchSciMat - STEMSub					0.017	0.002	7.025	0.000				
SES - SlfConSc - AchSciMat - STEMSub					0.019	0.003	7.209	0.000				
SES - PerValSc - STEMSub					0.031	0.006	5.247	0.000				
SES - EnjoySc - STEMSub					0.022	0.006	3.456	0.001				
SES - SlfConSc - STEMSub					0.012	0.005	2.148	0.032				
Sum of Indirect Effects (SES to STEMSub)					0.208	0.014	15.001	0.000				
Sum of Direct and Indirect Effects (SES to STEMSub)									0.223	0.027	8.160	0.000

	Direct Effects				Indirect Effects				Total Effects			
	B	SE B	Z	p	B	SE B	Z	p	B	SE B	Z	p
Native - STEMSub	-0.209	0.048	-4.405	0.000								
Native - EnjoySc - AchSciMat - STEMSub					-0.016	0.006	-2.648	0.008				
Native - PerValSc - STEMSub					-0.027	0.006	-4.259	0.000				
Native - EnjoySc - STEMSub					-0.020	0.009	-2.187	0.029				
Sum of Indirect Effects (Native to STEMSub)					-0.063	0.016	-3.858	0.000				
Sum of Direct and Indirect Effects (Native to STEMSub)									-0.272	0.052	-5.188	0.000
PerValSc - STEMSub	0.147	0.024	6.058	0.000					0.147	0.024	6.058	0.000
EnjoySc - STEMSub	0.107	0.029	3.688	0.000								
EnjoySc - AchSciMat - STEMSub					0.084	0.008	10.288	0.000				
Sum of Direct and Indirect Effects (EnjoySc to STEMSub)									0.191	0.029	6.512	0.000
SlfConSc - STEMSub	0.054	0.024	2.237	0.025								
SlfConSc - AchSciMat - STEMSub					0.085	0.009	9.796	0.000				
Sum of Direct and Indirect Effects (SlfConSc to STEMSub)									0.139	0.024	5.872	0.000
AchSciMat - STEMSub	0.091	0.006	14.463	0.000					0.091	0.006	14.463	0.000

Appendix 5

Direct and indirect effects on Physics subject choice (Unstandardised) (Pooled)

	Direct Effects				Indirect Effects				Total Effects			
	B	SE B	Z	p	B	SE B	Z	p	B	SE B	Z	p
Female - PhysicsSub	-0.515	0.046	-11.091	0.000								
Female - EnjoySc - AchSciMat - PhysicsSub					-0.027	0.005	-5.565	0.000				
Female - SlfConSc - AchSciMat - PhysicsSub					-0.038	0.005	-7.171	0.000				
Female - PerValSc - PhysicsSub					-0.027	0.006	-4.288	0.000				
Female - SlfConSc - PhysicsSub					-0.072	0.013	-5.654	0.000				
Sum of Indirect Effects (Female to PhysicsSub)					-0.164	0.021	-7.954	0.000				
Sum of Direct and Indirect Effects (Female to PhysicsSub)									-0.679	0.050	-13.623	0.000
SES - PhysicsSub	-0.044	0.030	-1.472	0.141								
SES - AchSciMat - PhysicsSub					0.133	0.011	12.471	0.000				
SES - EnjoySc - AchSciMat - PhysicsSub					0.022	0.003	7.153	0.000				
SES - SlfConSc - AchSciMat - PhysicsSub					0.023	0.003	8.133	0.000				
SES - PerValSc - PhysicsSub					0.039	0.006	6.254	0.000				
SES - SlfConSc - PhysicsSub					0.045	0.008	5.842	0.000				
Sum of Indirect Effects (SES to PhysicsSub)					0.262	0.017	15.849	0.000				
Sum of Direct and Indirect Effects (SES to PhysicsSub)									0.218	0.034	6.464	0.000

	Direct Effects				Indirect Effects				Total Effects			
	B	SE B	Z	p	B	SE B	Z	p	B	SE B	Z	p
Native - PhysicsSub	-0.362	0.054	-6.651	0.000								
Native - PerValSc - PhysicsSub					-0.034	0.008	-4.453	0.000				
Sum of Direct and Indirect Effects (Native to PhysicsSub)									-0.396	0.057	-6.982	0.000
PerValSc - PhysicsSub	0.184	0.024	7.661	0.000					0.184	0.024	7.661	0.000
EnjoySc - AchSciMat - PhysicsSub					0.105	0.010	10.721	0.000	0.105	0.010	10.721	0.000
SlfConSc - PhysicsSub	0.208	0.028	7.506	0.000								
SlfConSc - AchSciMat - PhysicsSub					0.108	0.009	12.034	0.000				
Sum of Direct and Indirect Effects (SlfConSc to PhysicsSub)									0.316	0.027	11.651	0.000
AchSciMat - PhysicsSub	0.114	0.006	19.337	0.000					0.316	0.021	14.912	0.000

Appendix 6

Direct and indirect effects on Biology subject choice (Unstandardised) (Pooled)

	Direct Effects				Indirect Effects				Total Effects			
	B	SE B	Z	p	B	SE B	Z	p	B	SE B	Z	p
Female - BiologySub	0.522	0.044	11.842	0.000								
Female - EnjoySc - AchSciMat - BiologySub					-0.009	0.002	-4.215	0.000				
Female - SlfConSc - AchSciMat - BiologySub					-0.013	0.003	-4.535	0.000				
Female - PerValSc - BiologySub					-0.026	0.006	-4.183	0.000				
Female - EnjoySc - BiologySub					-0.048	0.011	-4.412	0.000				
Sum of Indirect Effects (Female to BiologySub)					-0.096	0.014	-6.806	0.000				
Sum of Direct and Indirect Effects (Female to BiologySub)									0.425	0.045	9.374	0.000
SES - BiologySub	0.017	0.027	0.618	0.537								
SES - AchSciMat - BiologySub					0.046	0.009	5.003	0.000				
SES - EnjoySc - AchSciMat - BiologySub					0.008	0.002	4.475	0.000				
SES - SlfConSc - AchSciMat - BiologySub					0.008	0.002	4.369	0.000				
SES - PerValSc - BiologySub					0.037	0.006	5.794	0.000				
SES - EnjoySc - BiologySub					0.039	0.007	5.629	0.000				
Sum of Indirect Effects (SES to BiologySub)					0.137	0.014	10.071	0.000				

	Direct Effects				Indirect Effects				Total Effects			
	B	SE B	Z	p	B	SE B	Z	p	B	SE B	Z	p
Sum of Direct and Indirect Effects (SES to BiologySub)									0.154	0.028	5.473	0.000
Native - BiologySub	-0.048	0.045	-1.062	0.288								
Native - PerValSc - BiologySub					-0.033	0.008	-4.054	0.000				
Sum of Direct and Indirect Effects (Native to BiologySub)									-0.081	0.008	-4.054	0.000
PerValSc - BiologySub	0.174	0.024	7.198	0.000					0.174	0.024	7.198	0.000
EnjoySc - BiologySub	0.185	0.029	6.314	0.000								
EnjoySc - AchSciMat - BiologySub					0.036	0.007	5.089	0.000				
Sum of Direct and Indirect Effects (EnjoySc to BiologySub)									0.221	0.028	8.037	0.000
SlfConSc - AchSciMat - BiologySub					0.038	0.008	5.006	0.000	0.038	0.008	5.006	0.000
AchSciMat - BiologySub	0.036	0.007	5.261	0.000					0.036	0.007	5.261	0.000

Appendix 7

Overview of the ANZSCO codes and the fields of occupation information

ABS Cat. no. 1220.0 ANZSCO -- Australian and New Zealand Standard Classification of Occupations, Version 1.2

Released at 11.30am (Canberra time) 26 June 2013

Table 2: ANZSCO Version 1.2 Major and Sub-Major Groups

Major Group	Sub-Major Group		Predominant Skill Level(s)
1	MANAGERS		
	11	Chief Executives, General Managers and Legislators	1
	12	Farmers and Farm Managers	1
	13	Specialist Managers	1
	14	Hospitality, Retail and Service Managers	2
2	PROFESSIONALS		
	21	Arts and Media Professionals	1
	22	Business, Human Resource and Marketing Professionals	1
	23	Design, Engineering, Science and Transport Professionals	1
	24	Education Professionals	1
	25	Health Professionals	1
	26	ICT Professionals	1
	27	Legal, Social and Welfare Professionals	1
3	TECHNICIANS AND TRADES WORKERS		
	31	Engineering, ICT and Science Technicians	2
	32	Automotive and Engineering Trades Workers	3
	33	Construction Trades Workers	3
	34	Electrotechnology and Telecommunications Trades Workers	3
	35	Food Trades Workers	2, 3
	36	Skilled Animal and Horticultural Workers	3
	39	Other Technicians and Trades Workers	3
4	COMMUNITY AND PERSONAL SERVICE WORKERS		
	41	Health and Welfare Support Workers	2
	42	Carers and Aides	4
	43	Hospitality Workers	4, 5

	44	Protective Service Workers	2, 3, 4, 5
	45	Sports and Personal Service Workers	3, 4
5	CLERICAL AND ADMINISTRATIVE WORKERS		
	51	Office Managers and Program Administrators	2
	52	Personal Assistants and Secretaries	3
	53	General Clerical Workers	4
	54	Inquiry Clerks and Receptionists	4
	55	Numerical Clerks	4
	56	Clerical and Office Support Workers	5
	59	Other Clerical and Administrative Workers	3, 4
6	SALES WORKERS		
	61	Sales Representatives and Agents	3, 4
	62	Sales Assistants and Salespersons	5
	63	Sales Support Workers	5
7	MACHINERY OPERATORS AND DRIVERS		
	71	Machine and Stationary Plant Operators	4
	72	Mobile Plant Operators	4
	73	Road and Rail Drivers	4
	74	Storepersons	4
8	LABOURERS		
	81	Cleaners and Laundry Workers	5
	82	Construction and Mining Labourers	4, 5
	83	Factory Process Workers	5
	84	Farm, Forestry and Garden Workers	5
	85	Food Preparation Assistants	5
	89	Other Labourers	5

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